Winter January 2012

Energy Analysis & Utility Cost Mitigation With Storage for Commercial Buildings in California

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FOR

COMMERCIAL BUILDINGS IN CALIFORNIA

BY

ERIC ANTHONY FLEMING

FOR FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

December 2012

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by
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B.S.E. Mechanical Engineering
Loyola Marymount University, 2009

SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING FOR FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN MECHANICAL ENGINEERING
AT
LOYOLA MARYMOUNT UNIVERSITY, LOS ANGELES

DECEMBER 2012

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ACKNOWLEDGEMENTS

I am greatly indebted to my thesis advisor Professor Todd Otanicar for providing valuable direction and encouragement to conduct research in this domain.

I am also in debt to Professor Matthew Siniawski, for essentially, making this opportunity possible.

I am grateful to Anthony Florita of the National Renewable Energy Laboratory for providing a foundation for my research and providing valuable suggestions.

I am also grateful for the open data and publishing community, as this thesis report would not be in existence without it.

ABSTRACT

While on a great precipice of emerging energy technologies, it is necessary to understand how these technologies are most effectively integrated into current end-user systems. At the moment, 36% of California's energy consumption is demanded from the commercial buildings sector. This report investigates the nature of energy with the state of California through various sources and analysis techniques. Using specific weather and commercial building data, this paper also focuses on the analysis of Commercial Building energy demand modeling for the state's sixteen weather zones. It is modeled using the Department of Energy's tool: EnergyPlus and analysis is performed with R and MATLAB data manipulation software. R is utilized for clustering similar demand signal features for the set of demand profiles. MATLAB is utilized for electric cost savings, based on various applicable utility tariffs, using arbitrary storage apparatuses with variable size and efficiency. It was found that savings could be maximized by complex yet adaptive control algorithms and precisely sized apparatuses per building type/location. Electric Utility Providers can simplify the potential solution to energy storage with electricity tariffs, whilst eliminating statewide need for load following and peak power production.

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ABBREVIATIONS

Abbreviation	Meaning
CAES	Compressed Air Energy Storage
CAISO	California Independent System Operator
CBECS	Commercial Buildings Electric Consumption Survey
CPUC	California Public Utilities Commission
DOE	Department of Energy (US)
DSM	Demand Side Management
EES	Electrical Energy Storage
EIA	Energy Information Administration
CSS	Critical Storage Size
SDG&E	San Diego Gas & Electric
SCE	Southern California Edison
SMUD	Sacramento Municipal Utility District
FES	Flywheel Energy Storage
HVAC	Heating, Ventilation, & Air Conditioning
IOU	Investor Owned Utilities
ISO	Independent System Operator
LADWP	Los Angeles Department of Water & Power
LCA	Life Cycle Assessment
PJM	Pennsylvania New Jersey Maryland Interconnection LLC
NHAPS	National Human Activity Pattern Survey
PG&E	Pacific Gas & Electric
POU	Public Owned Utilities
PSH	Pumped Storage Hydroelectricity
TOU	Time of Use

1.0 Introduction

1.1 Overview: Energy in Perspective

Imagine a day in your usual life without electrical energy… You wouldn't be able to operate at full capacity. Most likely, you'd function at a mere fraction of the rate on a normal day. It's obvious that our human lives are reliant upon alternative forms of energy other than our own metabolic process. We demand more energy than we naturally create, because we are synergic with our ever so evolving technological domain, and technology needs energy.

Reasonably estimating the average daily solar absorption is 5 kilowatt-hours per square meter (kWh/m²), and the land area of California is: 403,465 square kilometers (km²), the state absorbs roughly 2 Petawatt-hours (PWh) of solar energy per day, or over 736 PWh per year, an overzealous amount compared to the states requirements. The solar radiation striking the Earth at any given time is 174 PW, or 4176 PWh/day. If you look at energy from a perspective in the theatrical making of 'The Matrix' our human bodies, on average, metabolically generate 2.2 kWh of energy per day. With a California population of almost 38 million people, that accounts for 30 Terawatt-hours (TWh) per year, or average 3,500 Megawatts (MW) instantaneous. While California's electricity demands are reach almost 300 TWh/yr, residents are relatively metabolically producing a mere 10% of their electric demand. [1]

It is our human nature to go beyond life's limits. The exploitation of our own kind would be a source of a civilization's energy along with the domestication of horses and other livestock. Water wheels and windmills assisted with this need over time until the mechanical advancements brought forth in the Industrial Revolution. Such inventions as steam engines could work harder, work longer, and work consistently, when applied properly.

As civilizations grow and technologies advance, so does demand for everything, and they still are today. The following figure shows a handful of prediction scenarios [2] for California's future annual electrical demand:

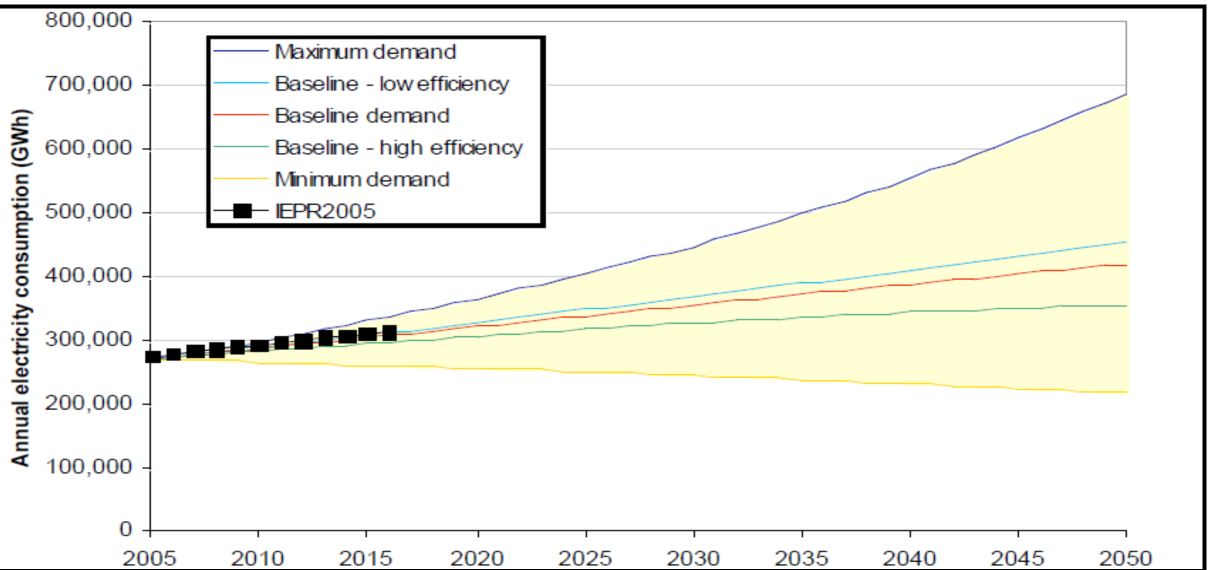


Figure 1.1 – Future Annual Electric Demand for California by Scenario

This growth is coinciding with gross state product, population, housing units, and employment. Annual demand growth is not the only dominating trend in energy. It has a daily peak in usage which has a slightly faster growth rate than annual demand. The following graph from The National Human Pattern Survey (NHAPS) shows our energetic bursts of activity throughout a typical day. [3]

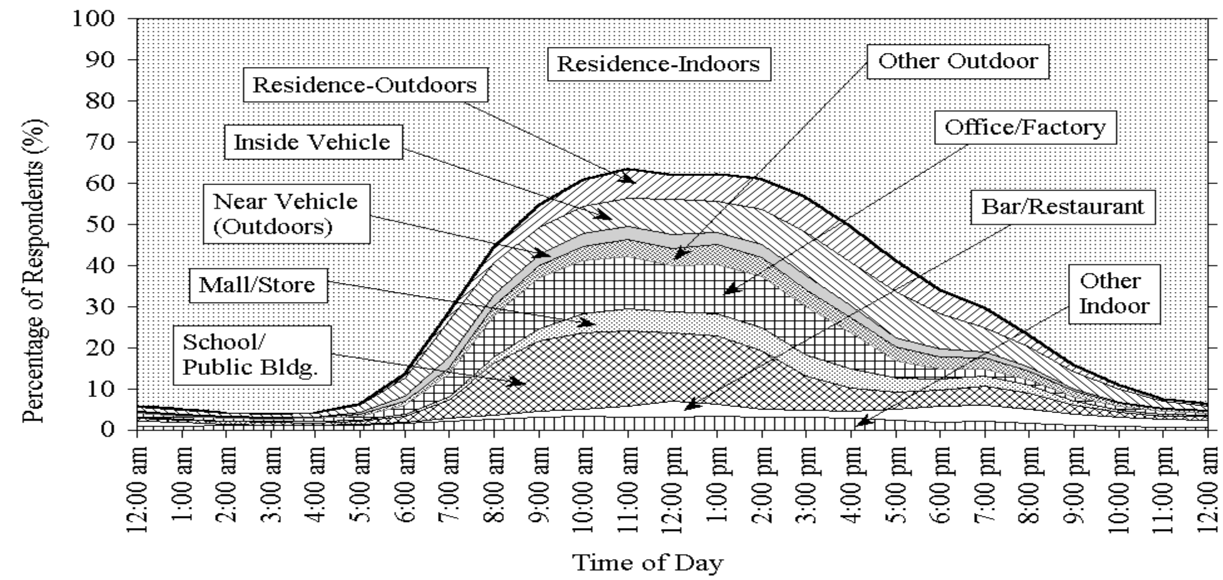


Figure 1.2 – A Day of Human Activity

Coincidental by our nature, our instantaneous electric demand is directly correlated with our activity. Whether we are driving, shopping, being educated, working somewhere, or just watching some television, most of us are more active during the day than the night. Moreover, most of our activities require some sort of energy source beyond ourselves. It shouldn't be a surprise that a daily graph of California's electric demand looks arguably similar.

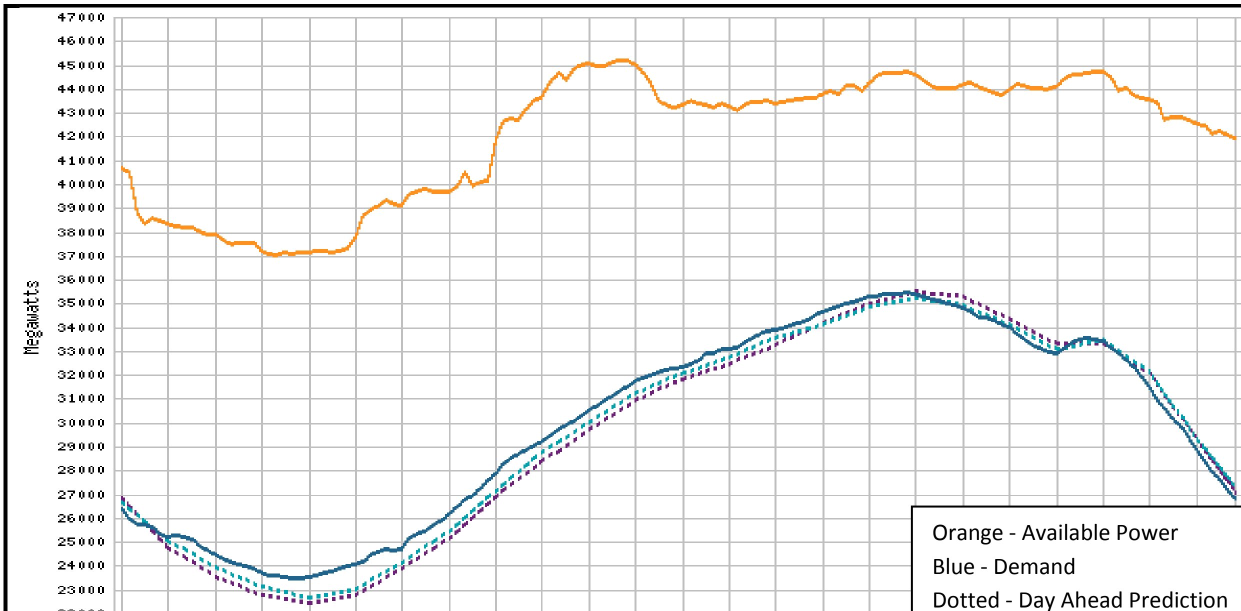


Figure 1.3 – A Day in the California ISO (July 2012)

The previous graph, a snapshot from the California ISO (Independent System Operator), shows the demand curve for roughly 80% of the total energy of the state. It has all but a handful of utilities participating. A key utility not in participation is the Los Angeles Department of Water and Power, whose service area is in the most electrically-demanding county in the state, using about one quarter of yearly statewide consumption. [4]

A 'double-humpback' and occasional delayed peak (winter months) from human activity to electric demand from the California ISO snapshot is an overall effect of thermal comfort technology. As the hottest time of the day comes in the later afternoon, the air-conditioners will come on to keep people comfortable. The figure below comes from this report's own simulations of the Heating, Ventilation, & Air-Conditioning (HVAC) system load of a large office building.

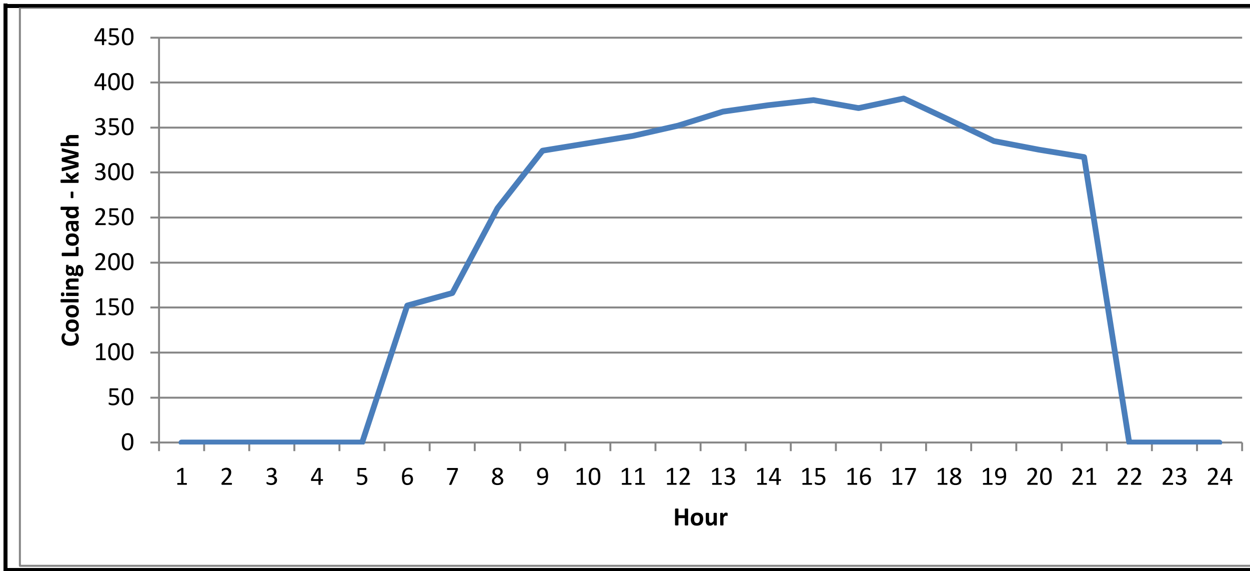


Figure 1.4 – A Day of HVAC Loads

Even as electric demand peaks at the end of the day with higher temperatures and HVAC loads, it has a lower per capita effect in California than other states. Climates vary from arid deserts to subarctic mountains. Weather also varies with latitude, elevation and coastal proximity. HVAC loads are generally subsidized by temperature stabilization from the Pacific Ocean. In fact, it is estimated that air conditioners account for at least 30% of summer peak loads in California. Average and peak daily temperatures cause significant variation in daily and peak demands respectively. As the coastal regions are becoming more densely populated, colonization toward the more harsh inland areas of the state will cause HVAC loads to increase in the not-so-distant future. [5]

The maximum instantaneous electric demand annually occurs in the month of July, August, or by chance September. According to the California Public Utilities Commission (CPUC), the state's highest peak demand recorded was 52,863 MW on July 10, 2002 at 3:01 pm. However, it is probable it has been surpassed. 42,441 MW of this demand was under control of the CAISO which has seen higher peaks in demand: 50,270 MW on July 24, 2006 at 2:44 pm. [4]

1.2 Methods for Billing Energy Use

In the first days of electrical power, people would be charged by how many light bulbs were in their building. With the need to charge customers for actual energy use came the famous mechanism based meters which would measure usage parameters as an analog signal. With the dusk of electromechanical energy meters and the dawn of digital ones, more complex forms of billing for energy usage are to come. Electromechanical meters could only read total energy used, or could read another parameter such as energy used in another part of the day, or maximum demand. Utilities could only differentiate rate tariffs between Summer and Winter, and maybe for peak or off-peak hours during the day. As digital/smart meters are becoming more widespread, they're allowing utilities to collect discretized data of your electric demand, in resolutions from 15 minutes to a second. This allows electrical utilities to apply the simple rules of economics effectively on your bi-monthly energy bill.

Time of Use (TOU) metering was created by electric utilities for energy demand management, also known as 'demand side management' (DSM), since it takes part on the customer's end. This practice is to encourage customers to use less energy during peak hours through education, which took part predominantly in the 1970's during a nationwide energy crisis and arguably today, or financial modeling, which occurs with TOU metering. Energy demand increases statewide on a daily and seasonal basis, the supply is strained, and as principal of supply and demand, value increases. If this is reflected in the customer's bill, one can alleviate costs as well as strain on the greater electrical system. Utilities structure these rates down to the hour, in two or three sections of the day: off-peak, semi-peak, and peak. These are terms coined by the utility Pacific Gas & Electric (PG&E); they vary from utility to utility. Rates may also be seasonal, differentiating the TOU rates in sections of the year: usually winter and summer sections. The more demanding the hour, day, or month, the more expensive your energy will be.

The energy crisis that California underwent in the turning years of the 21st century occurred because utilities could not meet high demand during hot summer days. This was mainly due in part to the failure of California's new and experimental competitive market for energy generation and transmission, and rapid growth, especially in Silicon Valley. PG&E would buy power out of state for as much as 30¢/kWh, while customers were paying 8¢/kWh with a State mandated freeze on electric tariffs. Starting in 2003, the CPUC mandated that all utilities start testing pricing schemes including demand surcharges. [6]

Demand metering has been in act by utilities since the late 19th century. Utilities realized that a critical requirement of their system was not only to provide enough energy, but also to provide enough power during times of high demand. As expenses to utilities rolled in when power plants needed to be fired up temporarily to meet demand (a very inefficient process), demand metering became more widespread. This metering has been a key cost on utility bills, more nowadays in California. Why? DSM.

1.3 Methods of Energy Storage

There are a handful of ways to store energy. Electrical Energy Storage (EES) systems, whether in market or development, may provide power on low, medium, and high (end-user, distribution, and generation) voltage levels. Many low and medium voltage applications may be utilized in commercial buildings.

1.31 Pumped Hydroelectric Storage

Pumped Hydro or Pumped-Storage Hydroelectricity (PSH) is one of the oldest storage technologies; it has been in place for over seventy years. The system uses a pump to store water in an elevated reservoir at night when energy is cheap and over supplied, and discharges that water during the day. The head pressure may drive the same pump backwards, rendering it a generator or a separate more efficient generator. Thirty-eight are in operation in the United States, eight of which are in California, with another several awarded preliminary permits in the state. [7] Despite being the most economical form of EES, it is only economical on large scales ranging between 40-1400 MW, which is required with the technology's capital costs of about $1000/kW output. These prices get low per quantity energy, at $100/kWh capacity. Round trip efficiency is between 70-80%. [8] Despite this system's economic feasibility, it would be far-fetched to attempt to design a system for a single commercial building in an urban environment.

1.32 Compressed Air Energy Storage (CAES)

Instead of pumping water up a hill, CAES technology pumps air into a manmade or natural subterranean vessel. Creating potential energy with pressurization during off peak periods, the pressure is discharged at peak in a hybrid process. The air is passed through a Natural Gas (NG) fueled combustor and de-energized through expansion turbines which drive generators. This uses a third of the NG to produce the same output as traditional NG plants. Roundtrip efficiency is about 85%. Roughly three-quarters of the land in the United States is suitable for natural underground storage. CAES plants have been constructed for as little as $400/kW. [8]

1.33 The Battery

In existence since the 20th century, traditional batteries have played an integral part in our lives, whether we've needed a few tenths of a volt or thousands. They are being used more often today, and they have desirable traits of modularity and quietness. They are currently installed in electric load centers and substations to serve as an uninterruptable power supply, increasing grid quality and reliability. Quick response to loads at twenty milliseconds and constant development are highly desirable qualities. Stationary batteries (non-vehicular use) currently cost at minimum $200/kWh (depending on technology) [9], are driven by competition in the electric automobile market, and are still dropping at greatly satisfying rates. Charge-to-discharge efficiencies range from 60-90% depending on the technology and cycles used. [8]

1.34 Flywheel Energy Storage (FES)

Still in much development is FES, which has taken part in electric grid quality and regenerative automotive braking. It involves the harnessing of kinetic energy of a rotating disc that can get very large in stationary applications. They have been used to power buses, regulate voltage in electrical distribution and light rail systems, and they are making their way into long term EES solutions. [10] The New York Power Authority recently installed ten 100 kW - 30 second systems for reliability. Smaller flywheels are seeing some commercial successes as they are rated for a variation of output schemes. Roundtrip efficiency is between 80-85%. Levitating flywheels are in development which would make this technology one of the quickest to come to full charge. [8]

1.34 Thermal Energy Storage

Solar-thermal power plants take advantage of natural energy storage traits in their heat transfer fluids, and can produce energy several hours after the source of the sun has fallen below the horizon. Mediums to store thermal energy involve molten salts, water, rocks, and even plain dirt. These mediums can transfer their thermal energy to a low boiling temperature refrigerant and power a turbine or heat a home. Ice is also being investigated, as one could make ice at night and use its high latent heat of fusion for cooling loads during the day. One cubic meter of ice can store 317,000 BTUs of cooling energy. [11]

1.4 Objective of Study

The analysis in this report first observes California's energy infrastructure as a whole, then looks into analysis of commercial buildings and monetary savings with a commercial grade energy storage system. Since DSM is becoming more predominant financially, it is becoming necessary to offset the charge with energy storage. In layman's terms, we are storing energy at night by arbitrary means with cheap utility power, and discharging it during the day to curb higher peak and demand costs. We are to conclude on the financial feasibility of such EES systems based on efficiency, storage size, and rate structure.

1.5 Limitations of Study

As this analysis looks into annual energy savings with storage, one drawback is a full life cycle analysis of such enabling systems. LCA would more accurately predict payback periods. This analysis also does not model actual storage systems, but an arbitrary storage apparatus of variable efficiency and size.

1.6 Organization of Research & Report

Research began with understandings of various EES technologies and applications. Section 2 observes the dynamics of energy in the state of California.

EES research is discussed in Sections 3 through 5 with generation of demand profiles for two sets of 16 different commercial buildings in California's 16 unique weather zones. Profiles were generated with the Department of Energy's software, EnergyPlus. These profiles were then passed through a Bayesian clustering algorithm with R software that batched the 512 building profiles into 38 unique clusters for savings result analysis. Profiles were then passed through a MATLAB program which computed annual costs for a set, or sets, of buildings in specific weather zones and specific utility tariffs. The MATLAB program simultaneously computes storage scenarios as well, and outputs annual costs with variable storage scenarios.

2.0 California's Energy System & Architecture

2.1 Statistics

The CAISO controls the second largest grid in the United States next to Pennsylvania New Jersey Maryland Interconnect (PJM) in the Northeast, and the fifth largest in the world. Beyond the ISO, California used 258.5 TWh of electrical energy in 2010, while generating 204.1 TWh. Peak summer capacity and total usage rank second among the states, while ranking third in oil refining capacity, fourth in net generation, and among the lowest in emissions. This somewhat expensive state holds an average price of 13.01 ¢/kWh of electric energy, eleventh highest in the country. [12]

The difference between net generation and net use requires California to import more energy from its neighbors than any other state. Inhabitants of the state use about 7.7 MWh/capita, well below the national average of 12 MWh/capita, which is believed to be an effect of temperate climates and DSM. However, regions of similar climates, such as Spain, use an average 4.5 MWh/capita. [6]

2.11 Demand Epicenters & Other Visual Statistics

California has two major metropolises in the San Francisco Bay and Los Angeles Metropolitan Areas, with considerable urban sprawl. The proceeding heat maps show the 2010 annual electricity usage by county and population. For annual electricity, the minimum light red values are 24 GWh, and maximum dark red value is 67,000 GWh.

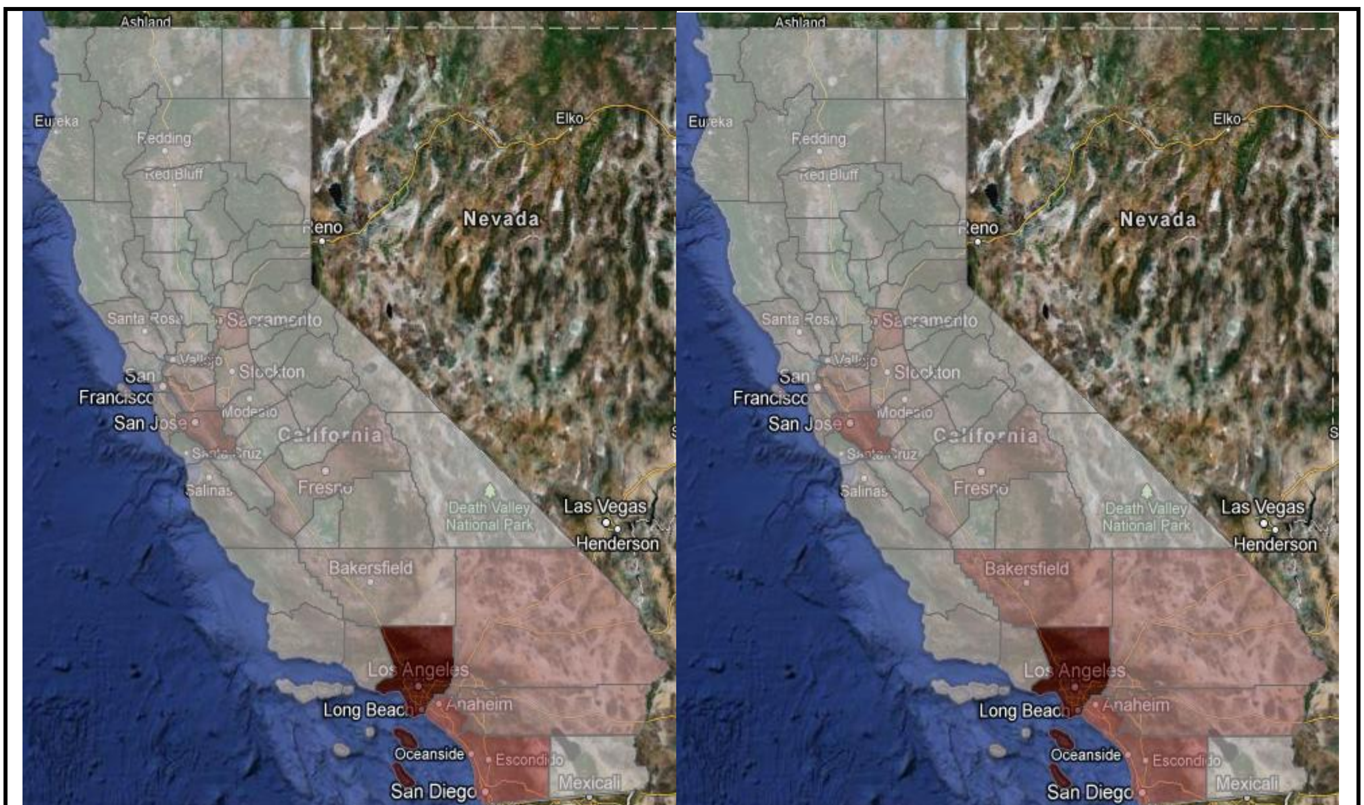


Figure 2.1 – Relative Annual Energy Usage by County (left) & Relative Population (right)

As it can be seen, there is a high correlation between population and energy usage. It is quite interesting to weigh this data with other parameters such as population and land area. The following heat map portrays usage density per square mile. Lower values are a mere 8 MWh/mi² with a maximum of 125,000 MWh/mi².

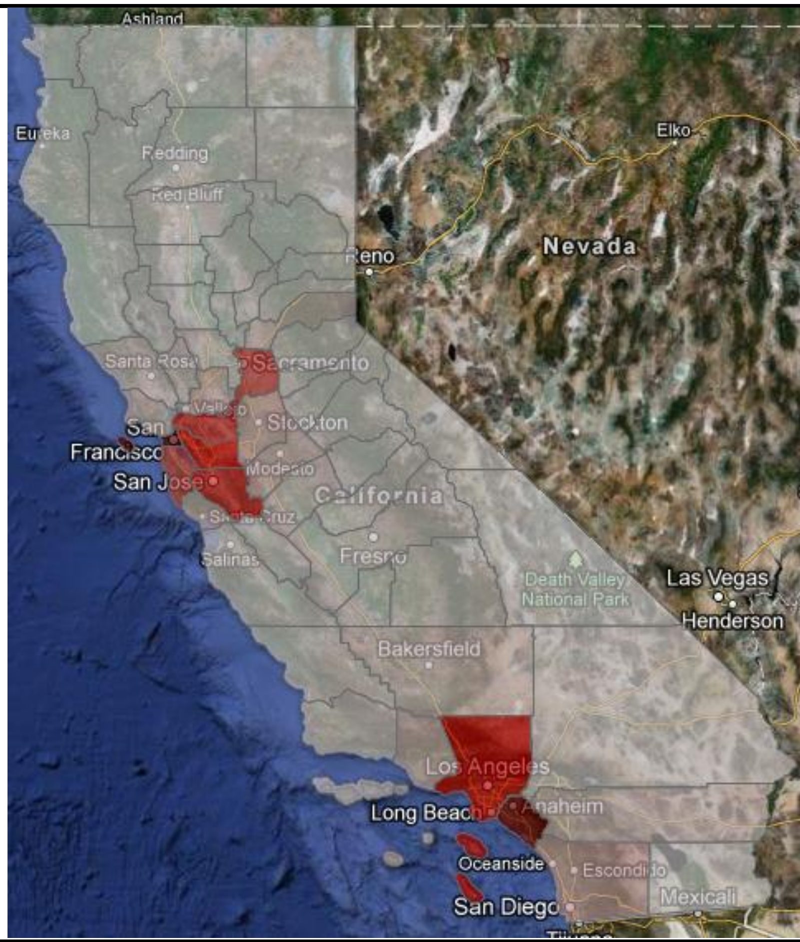


Figure 2.2 – Relative Energy Density per unit Area

The above map may easily depict likelihood of dense urbanization, as you would be able to see in a population weighted by area heat map. San Francisco County far surpasses the density of other counties with 125,384 MWh/mi² since the whole county is the city of San Francisco. Second in density is Orange County with 26,220 MWh/mi². Figure 2.2 accurately depicts the aforementioned metropolises of California.

Personal energy use is also quite dependent on location as well, especially in hotter areas where air conditioning systems are more intensely used. The proceeding heat map shows relative per capita energy usage.

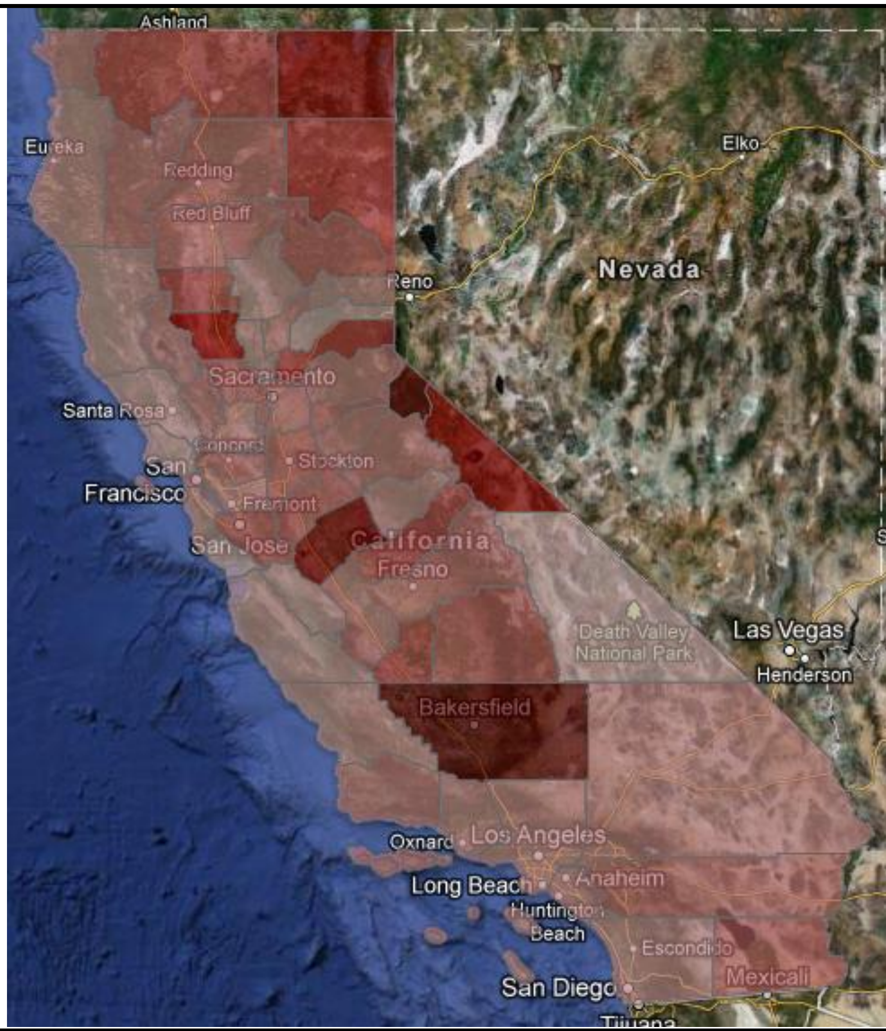


Figure 2.3 – Relative Energy per Capita

An anomaly south of Lake Tahoe, Alpine county, has very high per capita use of roughly 46,233 kWh/person. To put this in perspective, the next runner up in this parameter is Kern County with a per capita of 22,528 kWh/person. This may be explained by a very low population and high transient activity. There are several recreational areas such as ski resorts. Otherwise, per capita use is generally of higher relative value in the inland counties. More harsh climates exist inland, and thermal comfort technology is utilized more often than the coastal regions. As population growth continues, the tendency to colonize the hotter and more energy demanding inland counties will continue and will only lead to more intensive energy use. [6] Interactive heat maps and their relating tables may be found online in reference [13].

2.12 Transmission Interties

Since California is the biggest importer of energy in the United States many critical grid ties and interties exist in accordance between key electric utility providers. A majority amount of hydroelectric sourced power is imported via Path 15 and Path 66, consisting of the Pacific AC Intertie and California-Oregon Intertie respectively, from the northwestern states and Canada. DC power is imported to Southern California via Path 65 named the Pacific DC Intertie. Path 46 delivers over the combined capacities of Paths 15, 65, and 66 into Southern California from the

East. Its diverse sources consist of hydroelectric such as the Hoover Dam, gas and coal fired plants, and nuclear power from Palo Verde in Arizona. This path is ever expanding in order to supply growth in Southern California. Ties also exist with Baja California as its northern part is under the jurisdictions of the Western Electricity Coordinating Council. [14] Not much activity takes place at the Californian-Mexican border because of quality issues with the power in Mexico. However, wind and solar energy sources are expected to be imported into California from Mexico on a regular basis by the conclusion of 2013. [15]

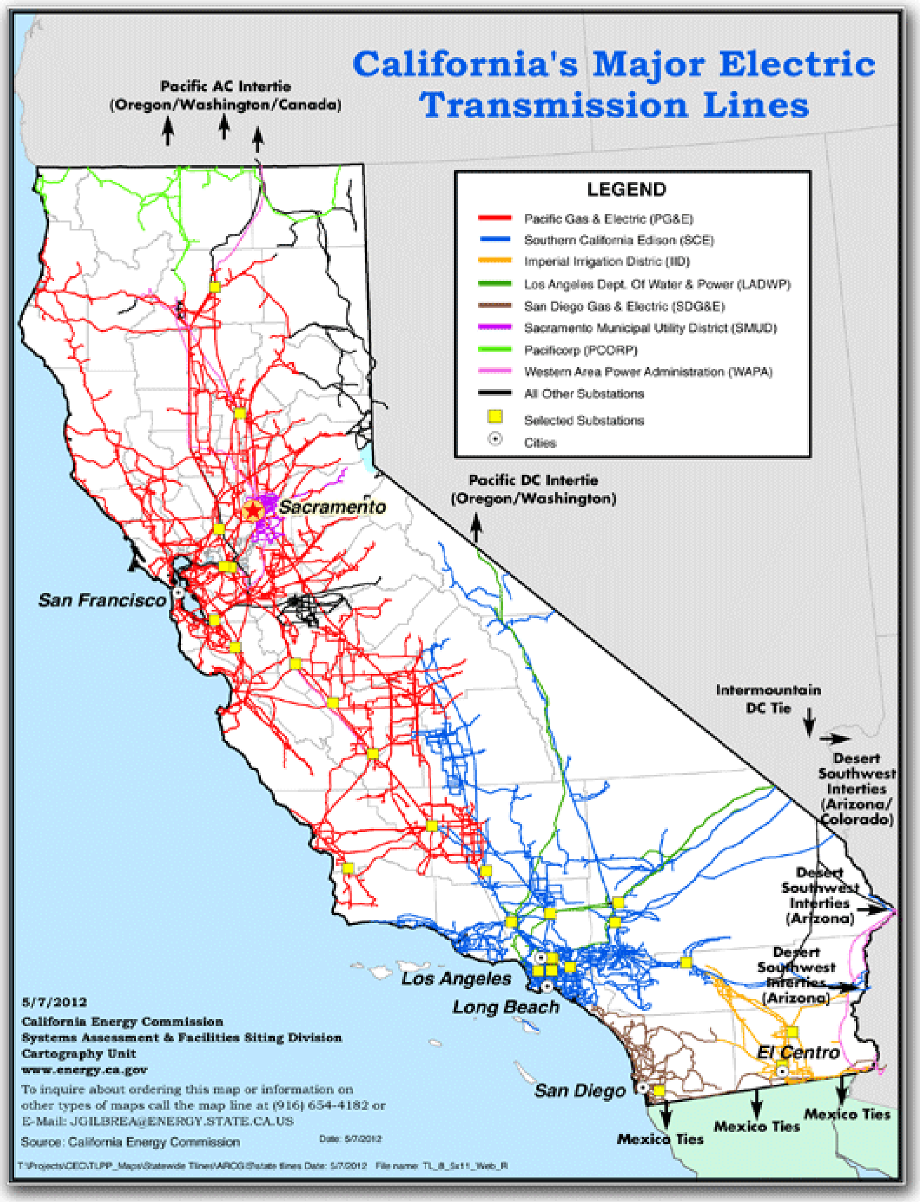


Figure 2.4 – Major Electric Transmission Lines

2.13 Generation Schemes

The State of California is not only home to a diverse mix of energy, but one which promotes and facilitates green alternative forms of energy. More energy comes from alternative sources than any other state. Sources existing from in-state coal are essentially non-existent due to strict environmental regulations. The proceeding table 2.1 shows California's diversified system power in the year of 2010. California has recently mandated a goal of 33% of energy from renewables by 2020. [15]

Fuel Type	In-State Gen (GWh)	Percent In-State	Northwest Imports (GWh)	Southwest Imports (GWh)	Power Mix (GWh)	Percent Power Mix
Coal	3,406	1.7%	783	18,236	22,424	7.7%
Large Hydro	29,861	14.6%	-	1,333	31,194	10.8%
Natural Gas	109,481	53.4%	1,330	10,625	121,436	41.9%
Nuclear*	32,214	15.7%	-	8,211	40,426	13.9%
Oil	52	0.0%	-	-	52	0.0%
Other	0	0.0%	-	-	0	0.0%
Renewables	30,005	14.6%	7,586	2,205	39,796	13.7%
Biomass	5,745	2.8%	1,149	-	6,894	2.4%
Geothermal	12,740	6.2%	-	673	13,413	4.6%
Small Hydro	4,441	2.2%	554	-	4,995	1.7%
Solar	908	0.4%	-	51	959	0.3%
Wind	6,172	3.0%	5,883	1,481	13,536	4.7%
Unspecified	0	0.0%	14,978	19,881	34,859	12.0%
Total	205,018	100.0%	24,677	60,492	290,187	100.0%

Table 2.1 – California's Energy Source Mix

2.2 Weather Zones & Micro-Climates

The California Energy Commission has designated sixteen unique weather/climate zones for the state under 'Title 24', far more than the three zones designated by ASHRAE 90.1. These climate zones are referenced to annual weather data for a day-by-day makeup of weather conditions for simulation. A zone may have mountainous terrain with an average elevation of 5,000 feet such as zone 16, or a coastal region such as zone 3. Latitude and topography affect the differentiating weather conditions. Figure 2.5 on the next page further depicts this for visualization.

However, California harbors much more that sixteen unique zones of weather due to enabling topography and a large coastline. These 'microclimates' may range from an acre of land to dozens of square miles. There may be as much as 20°F difference between cities on a summer day in Zone 3 within the San Francisco Bay Area. The microclimate effect is significantly predominant along coastal regions, where topography separates cold Pacific Ocean air and hot inland air. San Bruno Mountain, just a handful of miles south of San Francisco at a 1,300 feet elevation, experiences a significant temperature differential on its east and west faces. This may be characterized by cold humid coastal fog, high winds, and even soil makeup as a clay acts as thermal storage. Figure 2.5 geographically depicts the sixteen zones on the left, and topography on the right. Information on statistical parameters for these zones may be found in reference [16] and appendix A.

*As of the release of this thesis San Onofre Nuclear Plant has suspended operation, effectively halving the state's nuclear electric output. TBD if future re-start.

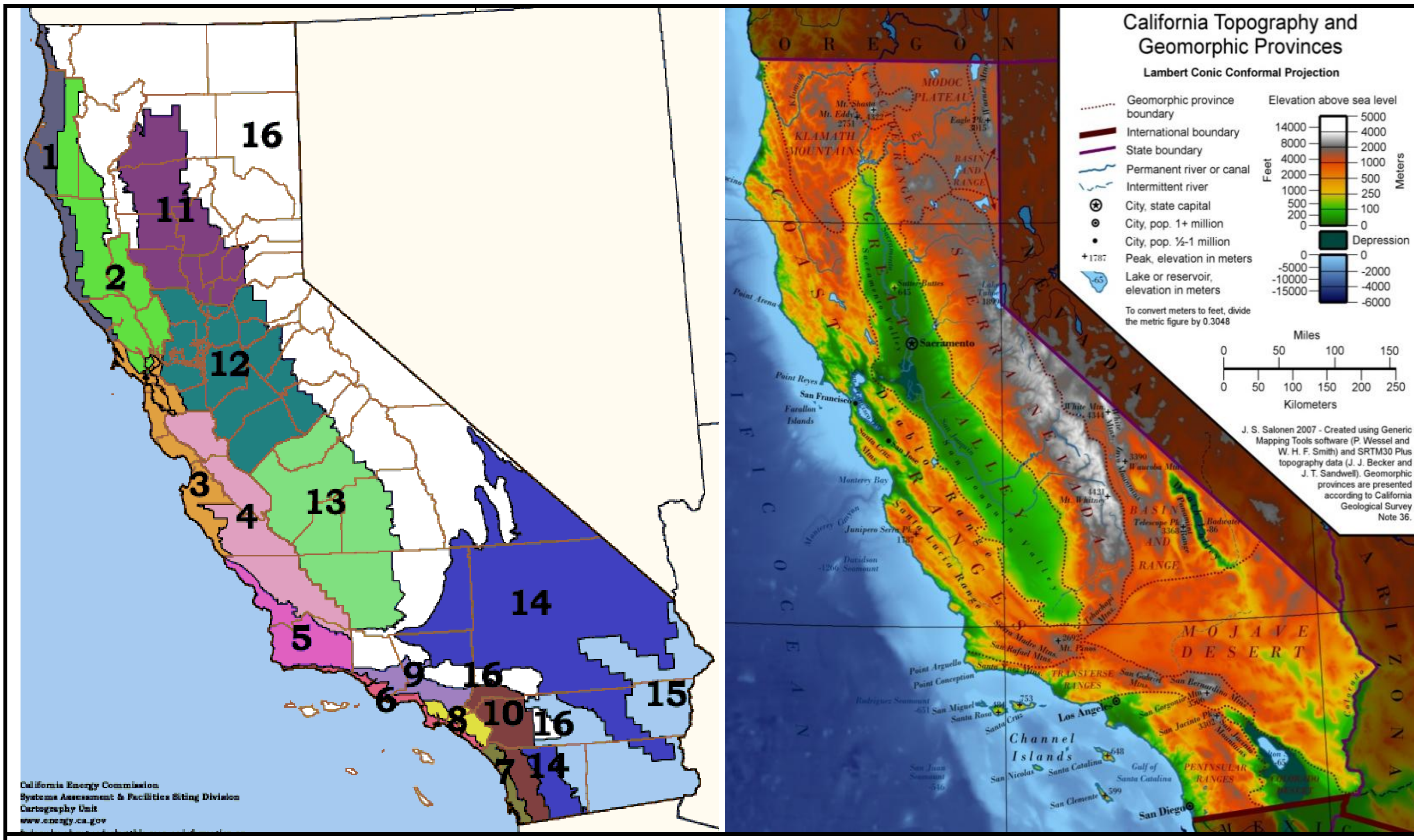


Figure 2.5 – California Weather Zones (left) & Topography (right)

Zones 1, 3, 5, 6, and 7 are all attributed with coastal weather trends such as fog, and differentiated with latitude and ocean temperature. Zones 2, 4, 8, 9, are characterized with hills and regulation from the Pacific Ocean, which prevents extreme temperatures. Zone 10 is hilly with thermal belts that trap cold air at night, have high average temperatures, and low humidity. Zones 14 and 15 are arid with high diurnal temperature swings yet differentiated with elevation. Zone 14 is medium/high desert which takes part in the great Basin of America, while zone 15 is low desert. Zone 16 is mountainous and extends from the Oregon border to the southern parts of the state in San Bernardino County. Climate varies with slope azimuth and elevation, yet cool temperatures and snow cover are predominating for half the year.

2.3 Utility Providers

California is home to six different inverter-owned utilities (IOU). These are Bear Valley Electric Services, Liberty Energy, Pacific Gas and Electric, PacifiCorp, San Diego Gas and Electric, and Southern California Edison. There are far more publicly-owned utilities (POU) which are usually run by sub-departments of municipalities.

All electric utilities report to a balancing authority such as the CAISO. There are ten of these authorities as of December 2011. Figure 2.6 shows maps of electric utility providers and balancing authorities. [15].

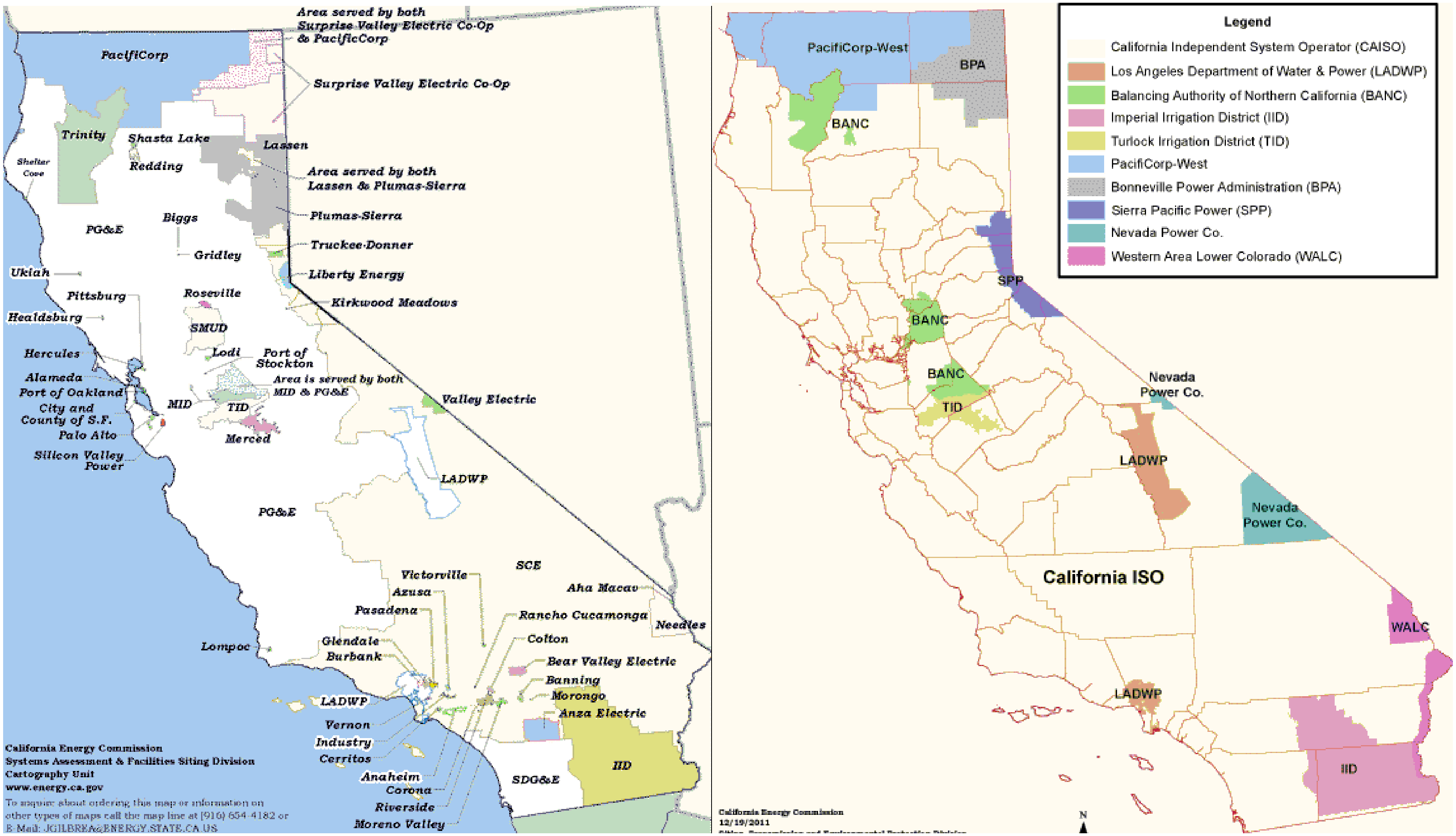


Figure 2.6 – Electric Utility Providers (left) & Balancing Authorities (right)

3.0 EnergyPlus & Demand Profile Generation

3.1 Building Types

The United States Department of Energy (DOE) has developed 256 models to represent roughly 70% of all commercial buildings in the country. Sixteen buildings for sixteen different cities, this report used thirty-two buildings, two sets each representing the two major metropolises: San Francisco (SF) and Los Angeles (LA). These models are designed from data collected by a handful of participants, the biggest being the Commercial Buildings Energy Consumption Survey (CBECS) datasets from the Energy Information Administration (EIA). The following table shows these sixteen different models and some small details. [17]

Building Type Name	Floor Area (ft²)	Number of Floors	Glazing Fraction
Large Office	498,588	12*	0.38
Medium Office	53,628	3	0.33
Small Office	5,500	1	0.21
Warehouse	52,045	1	0.006
Stand-alone Retail	24,962	1	0.07
Strip mall	22,500	1	0.11
Primary School	73,960	1	0.35
Secondary School	210,877	2	0.33
Supermarket	45,000	1	0.11
Quick Service Restaurant	2,500	1	0.14
Full Service Restaurant	5,500	1	0.17
Hospital	241,351	5*	0.15
Outpatient Health Care	40,946	3	0.19
Small Hotel	43,200	4	0.11
Large Hotel	122,120	6	0.27
Midrise Apartment	33,740	4	0.15

Table 3.1 – Commercial Building Types & Attributes

These buildings each have unique attributes, such as roofing, wall material, and style. They also contain a number of subsystems of which a typical building would have such as refrigeration, fans, boilers, chillers, elevators, etcetera, and have them sized accordingly. In fact, the main reason why there are SF and LA builds is that typical buildings in these areas have uniquely sized HVAC equipment. Other factors such as window properties differentiate between SF and LA builds. Full tables on the differences in build type for every building type are located with resource [17] and included in this reports electronic package.

3.2 Weather Zone Files

Each of California's weather zones described in section 2.2 have representative cites, or World Meteorological Organizations (WMO) nodes, which serve as a standard for the rest of the zone. Table 3.2 lists these details.

*Plus basement (not included in count)

Zone Number	Representative City	WMO #
Zone 1	Arcata	725945
Zone 2	Napa*	N/A
Zone 3	Oakland	724930
Zone 4	San Jose	724945
Zone 5	Santa Maria	723940
Zone 6	Long Beach	722970
Zone 7	San Diego	722900
Zone 8	El Toro	690140
Zone 9	Burbank	722880
Zone 10	Riverside	722860
Zone 11	Red Bluff	725910
Zone 12	Sacramento	724830
Zone 13	Fresno	723890
Zone 14	Barstow*	N/A
Zone 15	Imperial	747185
Zone 16	Mount Shasta	725957

Table 3.2 – Representative Weather Zone Cities

Each of these weather zones is simulated with several metrological parameters. Solar radiation is calculated along with the seasonal shifts of the suns position. Dry bulb, dew point, air, and ground temperatures are present in the data. Wind speed and direction is included as well. All these parameters play critical factors on a buildings HVAC load, as well as energy generated from renewable energy systems if present. This data is available in resource [17] and weather data summaries are available in appendix A.

3.3 Demand Profiles

Once collected, building models and weather zone files were paired in 512 combinations: 16 SF buildings and 16 LA buildings in 16 weather zones. Simulations were discretized to the hour, creating 8760 unique hourly demands each time.

Highest annual demand occurred with the hospital buildings at average 13 GWh/year, while lowest load occurred with the small office models at 65 MWh/year. Highest cooling loads typically occurred in weather zone 15.

Aggregated data by zone shows the more intensive weather zones due to HVAC loads. The most electrically intensive weather zone was zone 15, with the least in zone 1, taking the same places in cooling energy respectively. The most heating energy was required for zone 16, while the least was required for zone 15. Table 3.2 shows the aggregate sum of key energy parameters for buildings in each zone, and is available online for visual representation in reference [18] and this reports electronic package.

*All weather files had a WMO station number attached with the exception of Zones 2 & 14. In this case, the reference city was determined from resource [16]

	Total Electricity (MWh)	Total Heating (MBtu)	Total Cooling (MBtu)
Zone 1	51,770	54,336	41,508
Zone 2	53,856	51,093	47,726
Zone 3	53,720	45,542	47,531
Zone 4	54,661	44,513	50,043
Zone 5	54,243	43,086	49,041
Zone 6	55,588	36,690	52,838
Zone 7	56,028	35,579	54,383
Zone 8	56,301	35,542	54,923
Zone 9	56,345	35,675	54,842
Zone 10	56,405	35,920	54,665
Zone 11	55,421	49,017	51,461
Zone 12	54,953	47,894	51,009
Zone 13	56,606	42,222	55,945
Zone 14	56,152	44,289	49,909
Zone 15	60,927	30,781	66,987
Zone 16	52,437	65,790	40,124

Table 3.3 – Aggregate Energy Usage by Weather Zone

Generalized simulation data is available in Appendix B, while complete data is electronically included with this. Results will be further discussed, as well as visually analyzed, in section 6.

4.0 Simulation Clustering Classification

4.1 Purpose

To better understand the stockpile of 512 commercial building simulations, an algorithm was applied to the simulations' respective electrical demand profiles. Features of electrical profiles are extracted and compared for clustering in a three-step algorithm. First is a discreet wavelet transformation of these profiles, second is energy and entropy feature extraction from the wavelets, and third is a Bayesian probabilistic hierarchical clustering of features to group buildings of similar demand tendencies in absolute and relative domains.

Clusters group together with influencing factors such as building size/type and climate, which would force heating or cooling loads. These climatic tendencies for diurnal and seasonal HVAC load variation have an influencing factor on clustering. Classification was influenced by a total of 25 features extracted from each electric demand profile. Thirteen of these are relative wavelet energy features, four seasonal total entropy features, one yearly total entropy feature, four seasonal relative entropy features, and three moment-based (estimative statistics) relative entropy features.

Analysis was conducted of 4,820 total CBECS buildings (including non-commercial types) simulated in five U.S. weather zones designated by the CBECS. Florita [19] found that these weather zones did not have much of an influencing factor on clustering, therefore did not have much of an overall effect on the uniqueness of their relative electric demand profiles. Building type had much more of an effect on clustering. Where buildings of similar type were separated into different clusters, building size dictated differentiation.

4.2 Clustering Output

After clustering with Florita's [19] algorithm, a significant deal can be learned about generalized classifications of the electric demand profiles. Analysis of building type showed some of the most influence on clustering. When visually assessed with a heat map, as like Florita's method, one can see the heavy effect of building type on clustering.

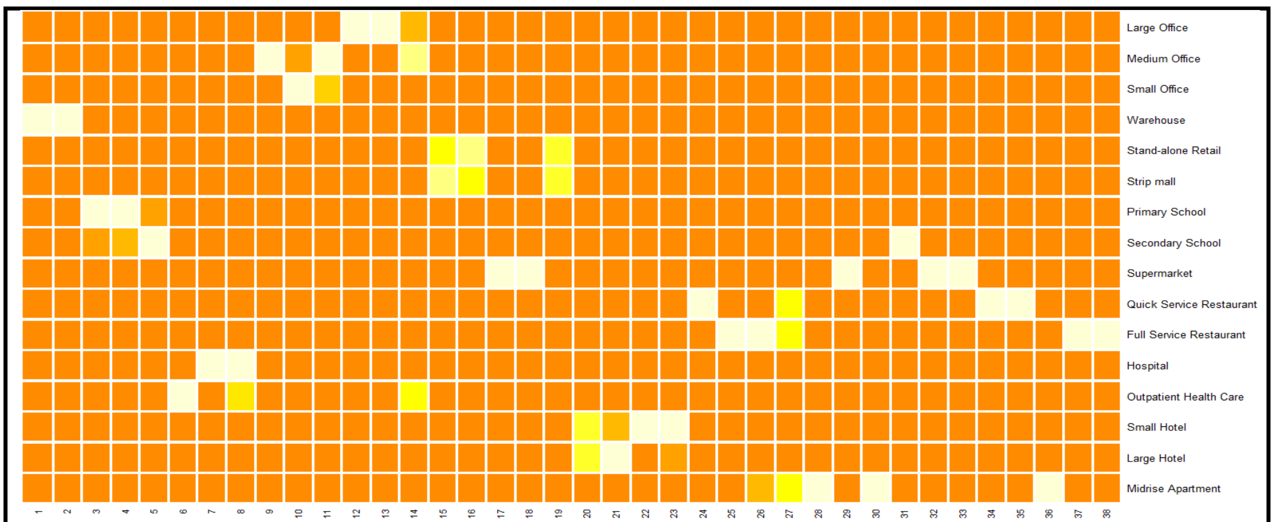


Figure 4.1 – Heat Map of Clusters by Building Type (white hot)

As it can be observed, clusters are heavily concentrated by type yet the same types are differentiated in some clusters. A possible explanation of this could be the effects of weather zone or building style. For example, clusters 12 and 13 contain 16 and 15 large office profiles respectively. What distinguishes these clusters apart are purely the effects of different weather zones. Data may seem scattered; however many clusters have been grouped with adjacent weather zones that share generalized characteristics.

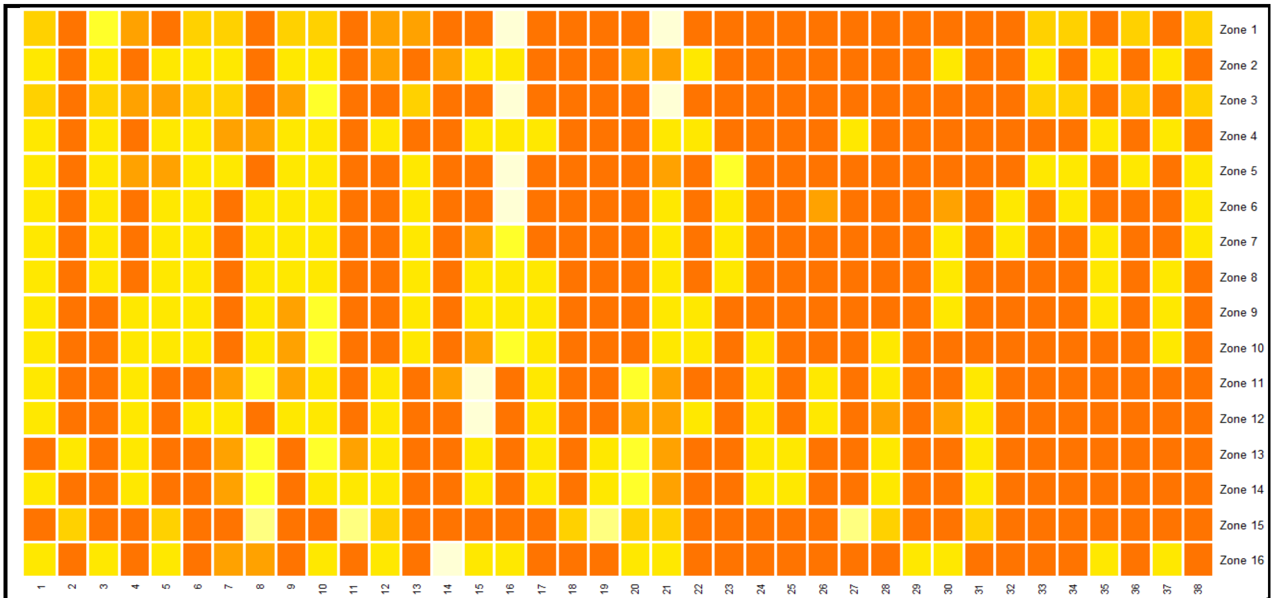


Figure 4.2 – Heat Map of Clusters by Weather Zone (white hot)

Since clusters 12 and 13 are not significantly influenced by building style (which will be discussed on the next page), it can be inferred that climate is the chief influencing factor. Figure 4.2 may seem scattered; however, many clusters have been grouped with adjacent weather zones that share generalized characteristics. When cluster concentration is geographically heat mapped, you can see this effect with ease. Cluster 12 harbors large offices inland, whilst cluster 13 contains those by the temperate coast.

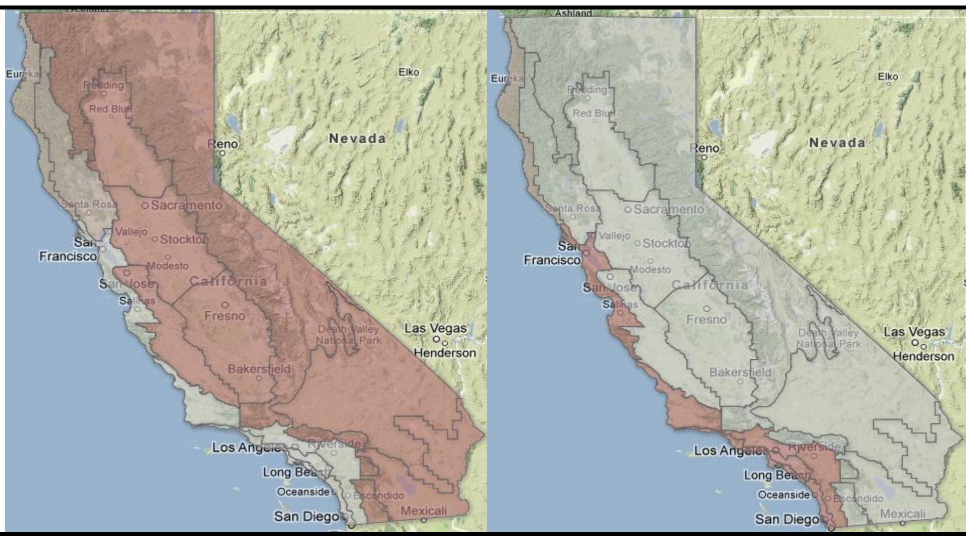


Figure 4.3 – Heat Map of Clusters 12 (left) & 13 (right) by Weather Zone (red hot)

Building style does have some noticeable effect on clustering. Most clusters contain an equal amount or insignificant difference of both San Franciscan and Los Angelean styles. Those clusters that do have imbalanced styles are clusters 7, 8, 10, 16, 19, 20, and 21. These clusters have an imbalance of at least three build styles and are represented in figure 4.4 with a heavy difference in heat mapping.

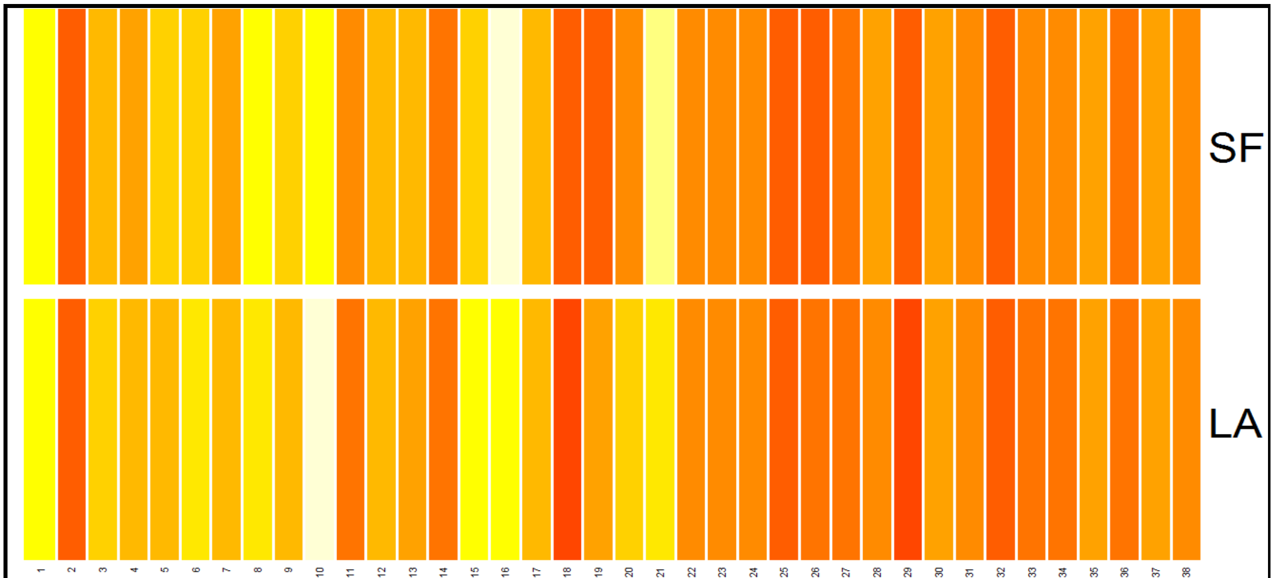


Figure 4.4 – Heat Map of Clusters by Build Style (white hot)

Clusters 7 and 8 are clusters of hospitals, which are not only differentiated by general weather zones but build types. Cluster 7 has a majority LA builds in coastal and central weather zones, yet cluster 8 inhabits SF builds in warmer and arid climates. Clusters 20 and 21 have somewhat of an opposite output.

Overall, clustering seems to be consistent with Florita's CBECS dataset applied to his algorithm. Building type was the predominating factor in clustering. Weather seemed to have more of an effect on clustering for this reports dataset, most likely explained by the sixteen various weather zones, compared to the five zones in the CBECS dataset. A parameter where there is nothing to compare it with is build type. Despite having several clusters weighted to a particular build type, more than two types are desired. As more weather zones were added in this dataset over the previous CBECS which provoked clustering, more build types can be implemented in such analysis and possibly yield similar findings. Appendix C contains tabulated data for each cluster. Visual data is also available in electronic form.

5.0 Rate Structure Analysis

5.1 MATLAB Logic

Since it was found that the program used to generate electric demand profiles; EnergyPlus version 6.0, contained a critical bug in its energy storage program, MATLAB was utilized to simulate annual costs. This was done with inputs from various utility tariffs currently active in the state of California, each being tied to its respective weather zones and commercial building types.

Each tariff file possesses input variables reflecting Time-of-Use rates and hours for off/on/super peaks for each season, as well as demand charges if applicable. The daysets for winter and summer seasons are also specified in this file. As well as options to specify the amount of tiers in a season's days which reflect the tariff, for example, not all tariffs have all three super/on/off peaks during the summer season, and some tariffs have the three tiers in the winter season, some have one tier for the winter season. This is specified with Boolean operators. An example set of tariff structure data used on Hospital buildings is shown below in Table 5.1. Tariffs are applicable to different buildings in the overall set depending on monthly demand or quantity of energy used.

Tariff	**PG&E E-20**	**SCE TOU8**	**LADWP A-2b**	**SDG&E AL-TOU**
Variables				
Tariff Weather Zones	[1,2,3,4,5,11,13,16]	[6,14,15]	[8,9]	[7,10]
Tariff Buildings	[2,4,18,20]	[2,4,10,18,20,26]	[1:32]	[1:32]
Winter Vars.				
Day sets	1:120 , 305:365	1:120 , 274:365	1:151 , 274:365	1:120 , 274:365
Off Peak Rate	$0.07016	$0.03901	$0.02252	$0.00799
On Peak Rate	0	0	$0.04045	$0.00874
On Peak Hours	[8,18]	[8,18]	[10,17]	[6,20]
Super Peak Rate	$0.08608	$0.06402	$0.04045	$0.01035
Super Peak Hour	8	8	13	17
Off Peak Hour	21	21	20	22
On Peak Demand	0	0	0	0
Super Peak Demand	$0.23	0	$4.25	$4.75
Max Demand	$11.72	$12.66	$5.00	$13.57
Month Set	[1,2,3,4,11,12]	[1,2,3,4,10,11,12]	[1,2,3,4,5,10,11,12]	[1,2,3,4,10,11,12]
Two Tier	1	1	0	0
One Tier	0	0	0	0
Summer Vars.				
Day set	121:304	121:273	152:273	121:273
Off Peak Rate	$0.06930	$0.04252	$0.01879	$0.00799
On Peak Rate	$0.09069	$0.07473	$0.03952	$0.00874
On Peak Hours	[9,18]	[8,18]	[10,17]	[6,18]
Super Peak Rate	$0.12313	$0.12613	$0.04679	$0.01138
Super Peak Hour	12	12	13	11
Off Peak Hour	21	23	20	22
On Peak Demand	$3.13	$4.53	$3.25	0
Super Peak Demand	$14.21	$16.08	$9.00	$7.65
Max Demand	$11.72	$12.66	$5.00	$13.57
Month Set	[5,6,7,8,9,10]	[5,6,7,8,9]	[6,7,8,9]	[5,6,7,8,9]
Two Tier	0	0	0	0

Table 5.1 – Various Tariff Rate Structures

Once a tariff file (or multiple) is correctly specified, it is side-loaded into the main 'ElectricUtilityCostProgram.m' MATLAB script. Starting at line 77 through 90, variables such as storage bank size and overall efficiency must be specified, as well as the number of tariffs the user is analyzing. The user must specify up to four tariffs to side-load on lines 83, 85, 87, and 89.

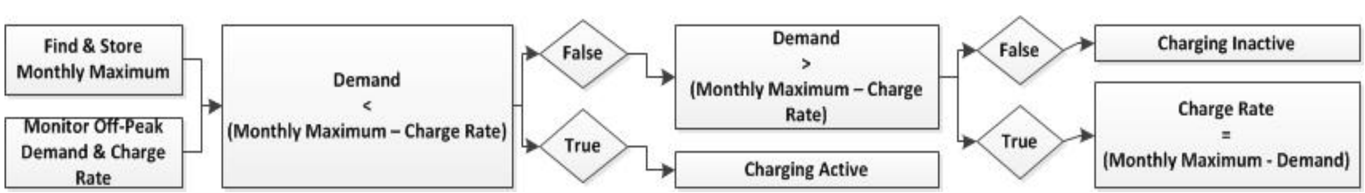
Charge and discharge is primarily determined by super-peak and off-peak hours of the utility tariff. The storage apparatus charges at cheap off-peak hours, and discharges at the most expensive times of the day. The user can choose to discharge solely across the super-peak or the on/super-peaks if three tiers are active; this is controlled via a Boolean operator. The control was found to have a negative effect on savings associated with storage. However, in some cases per building type, this would lower the respective demand profile's 'peak factor' which is the ratio of annual maximum demand to the annual mean demand.

5.11 Dumb Charge

The first iteration of this MATLAB program had a handful problems, one of which, charging underwent with no consideration of the future. This was found to have an adverse effect on savings associated with storage in the majority of simulations. The 'dumb charge' technique would indeed raise costs as well, creating a situation where it would cost money to operate storage. Virtually all tariffs have a charge for the maximum demand at any time, also known as a facility charge. Dumb charging would increase this portion of the tariff in many scenarios, negating savings effects from other TOU rates. This was confirmed with a significant increase in the peak factor.

5.12 Smart Charge

In order to alleviate the adverse effects of dumb charging, the algorithm was taught to look for the month's maximum demand (as demand charges are per month maximum) and never surpass that value when charging. It finds the difference between the maximum and present demands, and if it was less than the present charging rate, the rate would be modified to a lesser value or 0. This isn't exactly applicable control theory for the real world, but it works at alleviating the costs of dumb charging and mitigating the increase in peak factor. A diagram of this process as applied in the MATLAB file is pictured below.



5.2 Simple Time-of-Use Calculations

Energy storage savings for Time-of-Use rates can be calculated in the simplest form by using the energy storage offset with the key difference in rates and factoring with overall efficiency. It must be assumed the storage apparatus has a full charge and full discharge every cycle for the sake of simplification on an annual scale. The following formula calculates the monetary savings associated with offsetting energy usage only:

$$Annual\ Savings\ (\$) = Size \cdot\ [(Hi - Lo)(\#days)_{summer} + (Hi - Lo)(\#days)_{winter}] \cdot \eta \quad \text{[Eq1]}$$

where,

Size=Size of storage apparatus (kWh)
Hi=Highest rate for energy (¢ / kWh)
Lo=Lowest rate for energy (¢ / kWh)
#days=Number of applicable days in season
η=Overall Efficiency (% / 100)

This savings formula requires that discharging to be performed during the most expensive portion of the day, and it is bound by two key factors of a buildings demand profile. The first is what's called the critical storage size (CSS) in this report. CSS is a measurement of the minimum quantity of energy during the season for the tariffs discharge/super-peak hours. It varies from tariff to tariff and control strategy. Many buildings were analyzed for storage apparatuses sized beyond the respective CSS value nonetheless, and will be further discussed in Section 5.4. The other bound relates to the minimum demand rate during the discharge hours, meaning if the demand of the building is less than the discharge rate of the storage apparatus, monetary savings benefits will deteriorate. This is reflection upon the fact that most electric utilities pay little to nothing for putting energy back to the grid. However, in 2009 the California State Legislature and Gov. Arnold Schwarzenegger signed into law AB 920 which mandates public utilities to buy back surplus energy. The CPUC determined the rate for public utilities to buy back surplus energy. This rate is equal to the 12-month spot average for energy rates during the hours of 7am to 5pm and applicable for net-generators over the course of a 12-month period. Net-Generators may also request a kWh credit. [20]

The MATLAB program computes costs per hour, and because of its nature it doesn't always charge to full capacity in order to prevent higher facility charges. Therefore the formula above provides an upper limit to savings associated with TOU rates. It is also important to understand the program sells surplus energy back at the rate bought.

5.3 Demand Calculations

Demand costs are on a per month basis and must be analyzed in the same fashion. By nature they are more complex in mitigation since they are dependent on a much bigger set of time than TOU rates, yet may be bound within the TOU hours for the month. Facility charges may be the most common type of demand charge; it is the cost of peak electrical demand and is unbound by part of day. This can occur at midnight or in the afternoon. Utilities may also charge customers for maximum demand during other parts of the day such as the super-peak or on-peak, and are easier to mitigate than a facility charge since they are bound by certain periods of the day.

Direct mitigation of time bound demand charges luckily coincides with TOU rates, and the developed algorithm. However, instead of measuring the quantity of energy offset, the maximum power must be offset. More easily calculated post analysis, simplified savings may be assumed as:

$$Monthly\ Savings\ (\$) = Demand\ Rate \cdot\ [(Max\ Demand\ w/o\ Storage) - (\text{Max}\,Demand\ w/\ Storage)]$$
[Eq2]

where,

Demand Rate=Rate for peak power usage ($ / kW)
Max Demand=Peak Power (kW)

The same bounds apply for this equation as in the previous Eq1 section 5.2. It is critical to know that there is no simple way at alleviating maximum demand, as it is dependent on discharge rates, and heavily bound by CSS, since utilities don't give credit for negative demand. Unlike previously with TOU credit, this is reflected in the algorithm. Since it may be necessary to estimate savings based off tariffs alone, it is possible to estimate savings with an assumption of a constant discharge rate:

$$Monthly\ Savings\ (\$) = \frac{Demand\ Rate\ \bullet Size \bullet \eta}{\#hours\ in\ discharge}$$
[Eq3]

where,

Demand Rate=Rate for peak power usage during discharge ($ / kW)
Size=Size of storage apparatus (kWh)
η=Overall Efficiency (% / 100)
#hours=Number of applicable hours in discharge tier

An ideal control strategy for alleviating demand charges would implement variable discharge rates in order to "flatten" the demand curve and maximize savings. This MATLAB program uses a constant discharge rate calculated by the amount of energy stored during off-peak hours divided by the amount of discharge hours. It does not look into the future to prevent the EES apparatus from discharging at a rate which surpasses building demand.

5.4 Storage Bank Efficiencies, Sizes, & Applicable Utility Tariffs

In order to determine an adequate storage system, a minimum system efficiency should be established in order to benefit from cost savings. Not accounting for a full life cycle analysis (LCA), annual savings can be analyzed with various storage sizes, efficiencies, and applicable tariffs to determine an estimated payback time upon an investment of qualifying storage systems. Arbitrarily looking at the first building of the 512 building set, efficiencies are compared to savings and payback time with a storage size of 80 kWh (well below a CSS of 228.6 kWh) applied to a restaurant. All storage systems are assumed to have a $200/kWh cost.

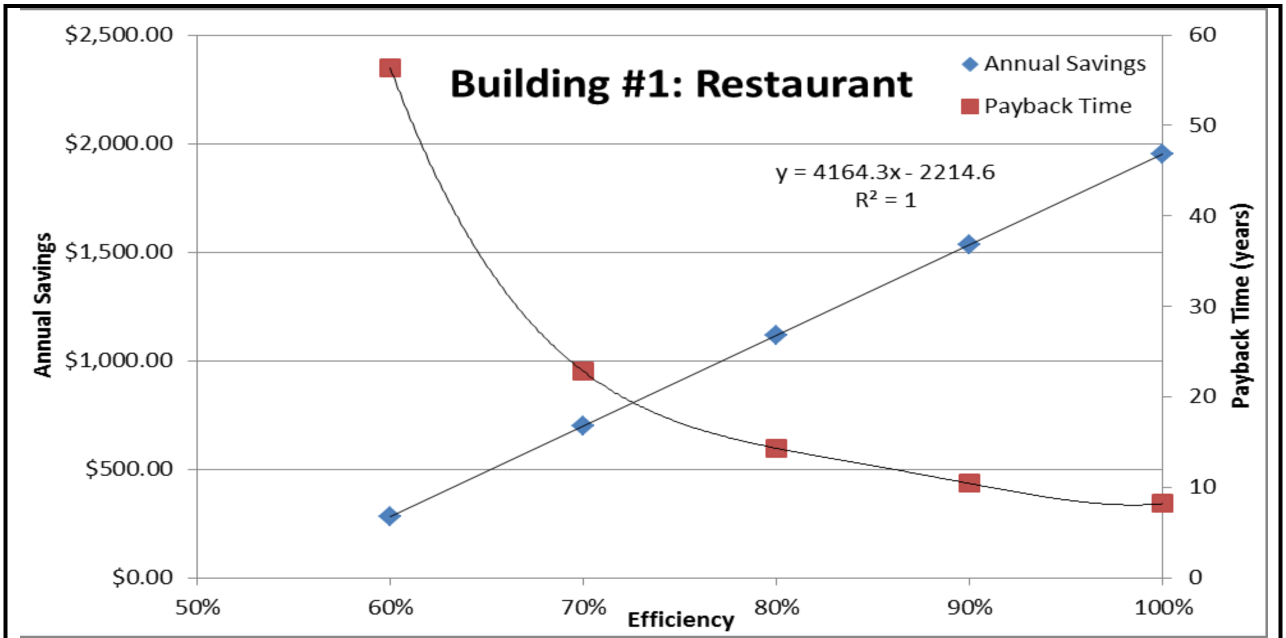


Figure 5.1 – Annual Savings & Payback Time for Various Efficiencies (80 kWh, PG&E E-19 Tariff)

As it can be observed, there is a direct linear relationship between efficiency and annual savings. However, there is a severe savings penalty as efficiency falls, especially under 75% efficiency. It should also be observed that there is a minimum efficiency of 53% to produce any savings at all under the programmed storage scheme, yet would be unrealistic since payback would be over lifetimes and beyond the bounds of a lifecycle for any storage technology available today. This is evidence that the developed control algorithm still requires significant development before it can be considered ideal.

Eyer [21] observed the benefits of PG&E's E-19 tariff with 80% efficiency and an idealized EES control program for total demand offset. This report from Sandia National Laboratories, determined a maximum of fourteen percent offset in total electric charges, or $81.2/kw-year. This report's analysis with 80% efficiency on an E-19 tariff has a maximum annual cost offset of six percent. Once again this supports the fact that the control algorithm requires development for 'idealness'.

Looking at various storage sizes, similar relationships may be inferred. As storage size is increased on an arbitrary simulation, the benefits decrease. This penalty is very present in fast food restaurants and small offices where savings becomes a cost of operation. This is once again because of oversizing of the EES technology. Figure 5.2 on the next page shows the annual savings and payback time of 80, 220, and 500 kWh storage sizes. This is applied to a hospital in weather zone two, on PG&E's E-20 tariff.

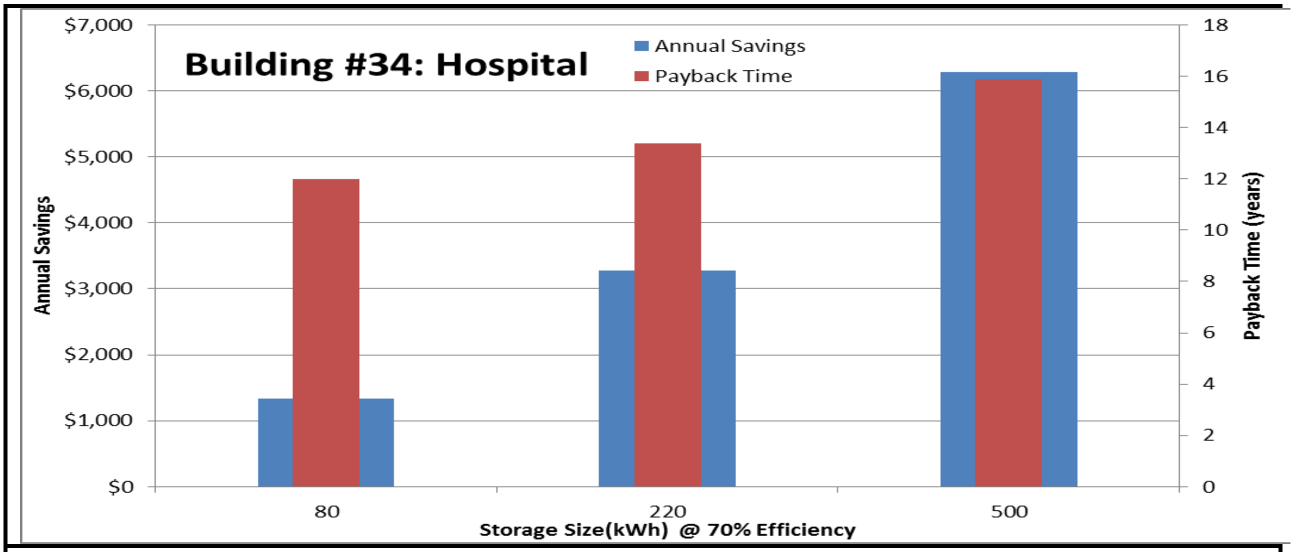


Figure 5.2 – Annual Savings & Payback Time for Various Storage Sizes (PG&E E-20 Tariff)

Despite significant increases in annual savings, the increment is not large enough to produce a decrease in payback time. This is partially in effect of the aforementioned 'smart charge' algorithm. Charging is being more often altered or seized with larger storage apparatuses and higher charging rates, in order to prevent an increase in facilities charges. Therefore the system is not benefitting from its full potential of storage.

5.41 Inadequate Efficiencies

Many instances arose upon analysis where 60% efficiency failed to produce savings with 80kWh of storage. Depending on zone/tariff, certain buildings would be affected. These buildings were fast food restaurants, small offices, hospitals, and large offices. These are profiles which are forced by weather zone to have a maximum demand during off-peak hours, and the charging scheme was severely devalued by 'smart charge.' Figure 5.5 shows a Fast Food Restaurant in weather zone sixteen which experiences this effect on a PG&E E-19 tariff.

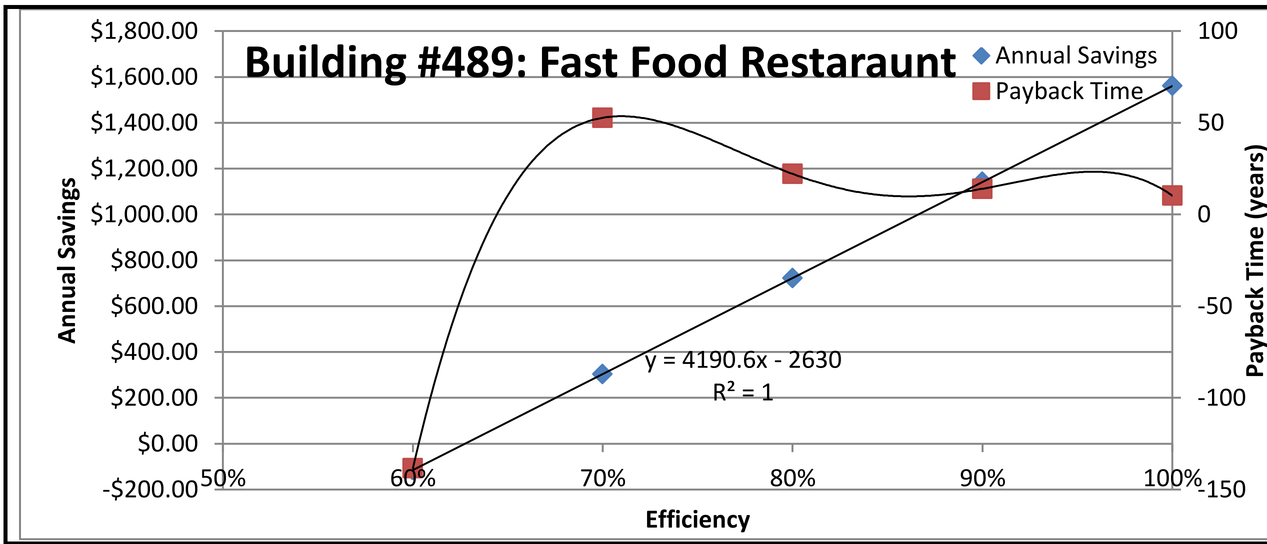


Figure 5.3 – Effects of Inadequate Efficiencies

Because of the limited data points available, 'payback time' in Figure 5.3 is not displayed in its true nature. While the data points hold valid, the matching curve does not. The function should be vertically asymptotic by nature, with the asymptote occurring around ~63%, the zero of 'annual savings. The left sided limit is negative infinity, while the right sided limit is positive infinity.

5.42 Oversizing

A fair amount of buildings are oversized for their respective CSS. 80 kWh sizes are oversized for warehouses and small offices. 220 kWh outsizes medium apartments, midrise apartments, fast food restaurants, and strip malls. Storage sizes of 500 kWh outsizes restaurants, outpatient clinics, primary schools, small hotels and retail shops, with each including the previous. A key set of buildings to observe with this oversized effect are restaurants with a CSS just above 220 kWh, and midrise apartments with a CSS just below 150 kWh. This can be speculated with adverse (negative) costs and savings values. The proceeding Table 5.3 shows this effect on midrise apartments under multiple scenarios. Savings is negated when oversizing a system which holds more energy than the amount used in the peak hours of a day. Such instances as in the following table for SDG&E's tariff AL-TOU were abundant in the savings data generated.

Midrise Apartments						**Savings @ η=100%**		
Building#	**WZ#**	**Cluster#**	**Tariff**	**CSS (kWh)**	**Annual Cost**	**80 kWh**	**220kWh**	**500 kWh**
198	7	30	AL-TOU	110.6	$13,645	$1,808	$1,839	$ (5,164)
246	8	30	A-2b	73.4	$15,507	$2,025	$5,126	$4,894
342	11	28	E-19	143.3	$37,892	$2,818	$5,833	$6,082
438	14	28	GS2	161.2	$31,350	$2,941	$6,178	$5,751

Table 5.2 – Various Oversizing Scenarios

Savings data is available in the electronic package under title: 'Savings.csv'.

5.43 Effects of Utility Tariff on Storage/Savings

One of the most influential variables (or set thereof) is the electric utility tariff. The tariff controls every parameter of potential for savings. Potential is created by minimizing of-peak rates, and maximizing the super-peak (or on-peak) for TOU scenarios. The tariff dictates CSS values as they are bound by the peak rate hours of the day. Figure 5.3 on the next page observes the average savings for all supermarkets with their respective tariff. They were chosen minding CSS is not to be exceeded by storage size. CSS ranged from 520-1322 kWh. Supermarkets are part of five distinct clusters, predominantly clusters seventeen and thirty-three.

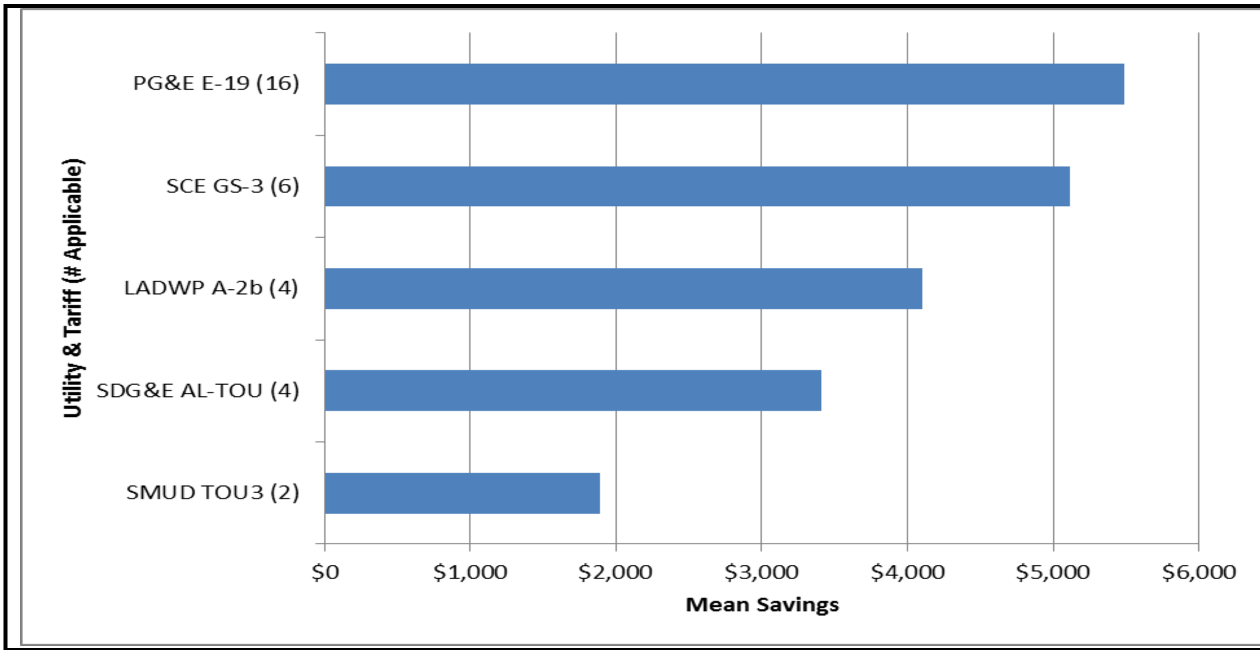


Figure 5.4 – Annual Mean Savings per Tariff for Supermarkets with 220 kWh Storage @ 80% Efficiency

It should be recognized that the highest summer super-peak demand rates exist in the same order as above. San Diego and Sacramento utilities, the two producing the least savings have distinct properties which perhaps limit their respecting storage savings. First, SDG&E's tariff introduces significantly more demand charges which puts into effect more savings modes over SMUD's. The SMUD TOU3 tariff also has a small summer season and a long winter season where savings can be relatively dormant in comparison with the summer season.

PG&E's tariffs set the baseline for savings performance. This may be explained with an exceptionally lengthy summer season. Savings has greater potential with large TOU rate differences and expensive super peak demand rates, as tariff E-19 possesses. Relatively expensive super peak TOU and demand rates are key providers to the economic feasibility of EES systems. On the other hand EES systems must be specifically calibrated to maximize savings from demand rates; otherwise savings is generalized as in Equation 3 of Section 5.3.

PG&E's E-19 tariff is also benefitted by an adequately sized and timed super-peak and the highest demand surcharge therein. The facilities charge is still cheaper than SCE and SDG&E. However one method to promote commercial energy storage is an abolishment of such facilities charge. Therefore charging a storage apparatus to full capacity is economically feasible every night, savings and electric load to the overall grid may be reduced further for peak hours.

Further refinement of EES potential with tariffs may include three tiers of rates. For example a system may be oversized some days, it would be nothing but beneficial to use extra energy to alleviate demand surcharge (and TOU) for on-peak rates. Essentially overall to economically incentivize storage, DSM tactics should be extensively used. A full set of tariffs used in this analysis may be observed with this reports electronic data package under root folder /MATLAB. Table 5.2 on the next page shows the rate structures incorporated into the simulation results of Figure 5.3.

Tariff	PG&E E-19	SCE GS-3	LADWP A-2b	SDG&E AL-TOU	SMUD TOU3
Variables					
Tariff Weather Zones	[1,2,3,4,5,11,13,16]	[6,14,15]	[8,9]	[7,10]	[12]
Tariff Buildings	[1:32]	[3,7,8,15,19,23,24,31]	[1:32]	[1:32]	[3,7,15,19,23,31]
Winter Vars.					
Day sets	1:120 , 305:365	1:120 , 274:365	1:151 , 274:365	1:120 , 274:365	1:151 , 274:365
Off Peak Rate	$0.07267	$0.03370	$0.02252	$0.00799	$0.074
On Peak Rate	0	0	$0.04045	$0.00874	0
On Peak Hours	[8,18]	[8,18]	[10,17]	[6,20]	[12,18]
Super Peak Rate	$0.08991	$0.04945	$0.04045	$0.01035	$0.0933
Super Peak Hour	8	8	13	17	8
Off Peak Hour	21	21	20	22	22
On Peak Demand	0	0	0	0	0
Super Peak Demand	$0.21	0	$4.25	$4.75	0
Max Demand	$11.85	$13.30	$5.00	$13.57	$3.40
Month Set	[1,2,3,4,11,12]	[1,2,3,4,10,11,12]	[1,2,3,4,5,10,11,12]	[1,2,3,4,10,11,12]	[1,2,3,4,5,10,11,12]
Two Tier	1	1	0	0	1
One Tier	0	0	0	0	0
Summer Vars.					
Day set	121:302	121:273	152:273	121:273	152:273
Off Peak Rate	$0.06879	$0.04501	$0.01879	$0.00799	$0.0975
On Peak Rate	$0.09502	$0.07044	$0.03952	$0.00874	$0.1227
On Peak Hours	[9,18]	[8,18]	[10,17]	[6,18]	[12,20]
Super Peak Rate	$0.13357	$0.10406	$0.04679	$0.01138	$0.1796
Super Peak Hour	12	12	13	11	14
Off Peak Hour	21	23	20	22	22
On Peak Demand	$3.41	$3.08	$3.25	0	0
Super Peak Demand	$14.59	$12.96	$9.00	$7.65	$6.85
Max Demand	$11.85	$13.30	$5.00	$13.57	$3.40
Month Set	[5,6,7,8,9,10]	[5,6,7,8,9]	[6,7,8,9]	[5,6,7,8,9]	[6,7,8,9]
Two Tier	0	0	0	0	0

Table 5.3 – Various Tariff Rate Structures in Accord w/ Fig.5.3

5.5 Correlations of Clustering & Savings

A quick analysis of the mean savings in each cluster, with 80 kWh at 100% efficiency is performed. This is to speculate upon whether certain clusters may prove more economically feasible than others for utility cost mitigation with energy storage. Clusters #10, #24, and #34 have the least savings and consist of small offices and fast food restaurants. Among the highest in savings were clusters #11, #19, and #31; consisting of medium sized offices, retail stores, strip malls, and secondary schools. Cluster #10 consists of small offices and is plagued by low CSS values of ~10kWh. Clusters #24 and #34 are made of fast food restaurants which did not adapt to the control algorithms well.

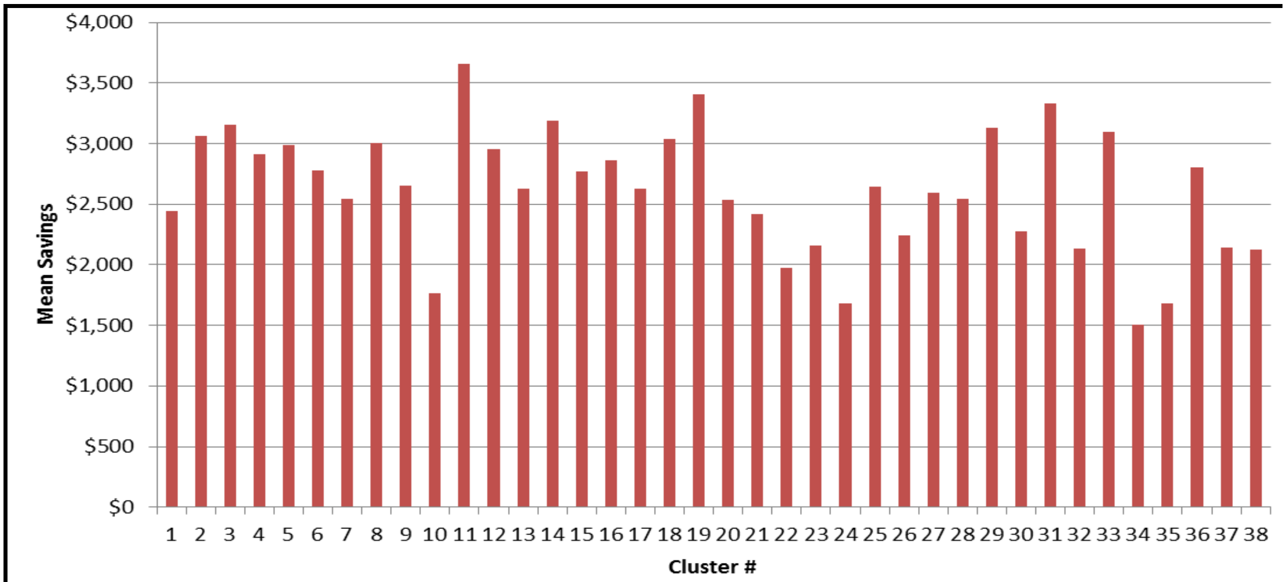


Figure 5.5 – Average Annual Savings per Cluster

Clusters producing the most savings tended to be in the more inland and arid weather zones. Furthermore, clusters producing the least savings were seemingly more influenced by building type. However cluster thirty-four is coastal, which may indicate thermally regulated coastal climates has an adverse potential for EES savings. A study of the clusters shows that multiple tariffs may be associated within.

Building types and weather zones more often influenced the monetary savings within the clusters. This was an effect of the non-ideal control strategy. If the control was idealized, then the only influencing factors on savings would be of the tariff rate structures. Specific tariffs would have some overall influence maximizing the savings within the grouping, most often being a PG&E tariff. Figure 5.6 shows the geographical mappings of clusters: 10, 11, 19, and 34 (left to right). A full makeup of the clusters is available in the appendix; while a full set of cluster maps are within the data package.

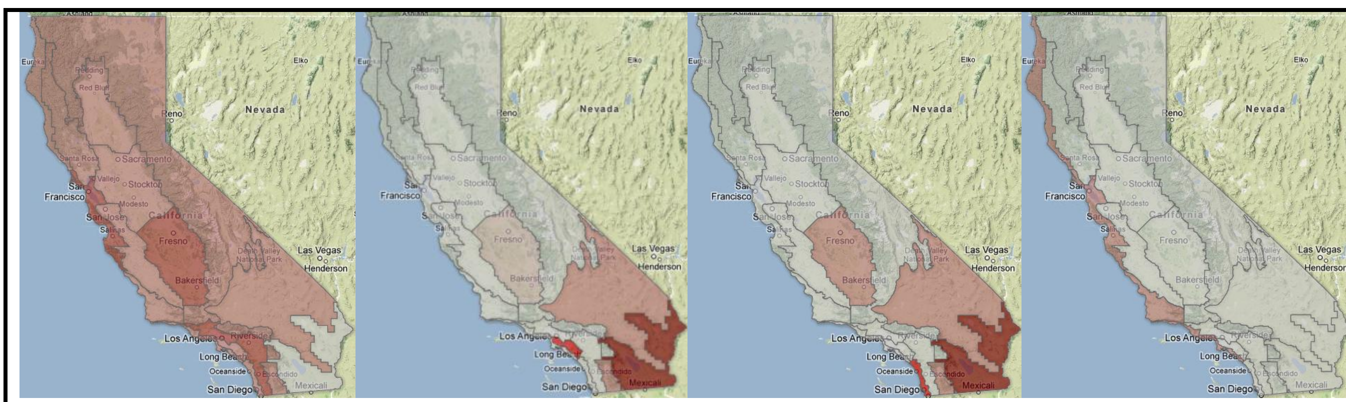


Figure 5.6 – Weather Zones of Select Clusters 10, 11, 19, & 34 (left to right)

6.0 Conclusions

California is a rich and vibrant culture, synergetic with energy, generating it from a vast portfolio of growing alternative resources, and consuming it with advanced technologies and a highly active population. While the San Francisco Bay and Los Angeles Metropolitan areas are the epicenters of energy usage, inland 'Central California' regions are higher per capita, and population growth is promoted in those regions due to high coastal populations and lower expenses of living, accelerating statewide energy usage growth. This will lead to higher peaks in system use, and will further facilitate the necessity for demand offsetting EES.

Florita's clustering algorithm was successfully applied to the 512 building set representing California in its 16 weather zones, yielding 38 unique groups of buildings. It was concluded that this clustering indeed has an effect on potential savings, at least for the applied control strategy. However, it would be rather difficult to conclude on which clusters would yield maximized savings without simulating a tariff rate. Extracted features of clusters would have to go through further independent and in depth analysis to find a connection between clustering and savings.

Tariff rate and structure was a significant influence on potential savings in simulation, and with an idealized storage scheme, it would be the key influence upon savings. As decades pass, peak demand should continue its trend at growing faster than overall consumption [4], unless a market is to be incentivized to do something about it. The need for widespread demand offsetting technologies is required for California's energy agenda on all voltage levels, from residence to commercial building to substation to generation.

Utility Tariffs could incentivize energy storage on a commercial end user level, a 3,500 MW market potential, and Figure 2.2 shows where this potential may be located. Utilities themselves could also incorporate large systems in sub-stations, a 5,000 MW market potential. [21] Figure 2.3 may show where sub-station storage could be feasible, since commercial development is relatively low, and the electric loads of countless air-conditioners could be offset.

There are strong limitations to AB 920 with applications for energy storage, as you can't over-design a storage system to your buildings need, and must be a net-generator over the course of a year. Private Citizens and businesses should be incentivized to recycle wasted base load and wind energy during the night with special tariffs. Simple TOU economics will not incentivize enough unless more extreme rates are enacted on tariffs. Elimination of the facilities charges could provide incentive to store energy. Special tariffs for energy storage customers could have this trait to promote storage on all levels, as well as providing real-time value to surplus energy. In an ideal case, promotion to store energy could be achieved with fire sales of wasted off-peak energy.

Essentially, savings could be maximized by extremely complex yet adaptive control algorithms and precisely sized apparatuses per building type/location. If utilities are looking for a new form of DSM, a multitude of commercial EES systems can offset a sizeable chunk of grid wide peak load. Electric Utility Providers can significantly simplify the potential solution to energy storage with new and improved tariffs for EES, whilst eliminating statewide need for load following and peak power production.

7.0 Future Work & Analysis Recommendations

- Program weekends and holidays into MATLAB script.
- Prevent oversizing of storage apparatus by setting a warning that the EES is oversized for CSS.
- Create a variable for discharge control: ‘Critical Storage Rate’ which is the maximum discharge rate. Create ‘smart discharge’ logic.
- An EES charge/discharge control strategy such as used with the CAISO with day-ahead, and hour-ahead demand predictions.
- Analysis with ‘ElectricUtilityCostProgram.m’ concerning relationships with variable discretized tariff rates. Expanding study to use arbitrary utility tariffs. Design tariffs for ideal commercially sized EES economics.
- Study simulations without facilities charges.
- Expand study to sub-station demand signals, enabling study of large scale high voltage electric energy storage systems.

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Appendices

Appendix A: Weather Zone Data

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 1, CA, USA
	Latitude/Longitude:	40.8° North, 124.2° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00001 725945 WMO Station Number, **Elevation** 13 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	229	282	329	462	461	452	433	427	400	329	217	197	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	260	275	238	396	369	319	304	297	326	353	191	245	Wh/sq.m
Diffuse Radiation (Avg Hourly)	129	150	196	206	207	223	216	221	194	144	136	111	Wh/sq.m
Global Horiz Radiation (Max Hourly)	491	661	767	927	968	982	974	949	847	716	534	406	Wh/sq.m
Direct Normal Radiation (Max Hourly)	843	907	921	917	905	906	906	891	864	853	805	779	Wh/sq.m
Diffuse Radiation (Max Hourly)	843	907	921	917	905	906	906	891	864	853	805	779	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	1721	2505	3301	5185	5911	5936	5671	4921	4238	3055	1723	1466	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2178	2645	2590	4600	4826	4302	4078	3459	3501	3327	1641	2039	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	977	1342	1968	2335	2670	2945	2848	2577	2088	1363	1090	831	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	9	9	10	10	12	14	14	14	14	13	10	9	degrees C
Dew Point Temperature (Avg Monthly)	7	7	8	7	9	12	12	13	12	11	6	7	degrees C
Relative Humidity (Avg Monthly)	86	84	87	78	83	86	83	91	85	88	76	89	percent
Wind Direction (Monthly Mode)	140	140	140	330	320	330	330	320	350	320	150	90	degrees
Wind Speed (Avg Monthly)	2	3	3	3	3	3	2	2	1	2	2	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	9	10	10	11	12	13	13	13	12	11	10	10	degrees C

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 02, CA, USA
	Latitude/Longitude:	38.4° North, 122.7° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00002 C00000 WMO Station Number, **Elevation** 50 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	357	297	431	555	487	604	573	555	505	413	281	234	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	536	269	408	589	432	625	565	547	586	550	431	311	Wh/sq.m
Diffuse Radiation (Avg Hourly)	138	168	182	160	180	152	170	175	140	120	89	110	Wh/sq.m
Global Horiz Radiation (Max Hourly)	620	769	921	968	1016	1004	924	885	820	714	589	554	Wh/sq.m
Direct Normal Radiation (Max Hourly)	1036	984	1084	962	925	915	787	794	815	846	887	925	Wh/sq.m
Diffuse Radiation (Max Hourly)	1036	984	1084	962	925	915	787	794	815	846	887	925	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2704	2696	4300	6229	6053	7901	7457	6251	5365	3858	2298	1735	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	4484	2478	4253	6898	5407	8242	7405	6302	6288	5310	3614	2373	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1075	1536	1848	1827	2271	2020	2233	2034	1529	1170	764	839	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	7	10	11	13	16	19	20	19	18	15	10	8	degrees C
Dew Point Temperature (Avg Monthly)	3	6	7	5	9	7	8	7	7	5	6	5	degrees C
Relative Humidity (Avg Monthly)	81	82	77	66	67	51	50	50	56	57	78	86	percent
Wind Direction (Monthly Mode)	160	160	160	320	160	290	160	320	320	320	320	160	degrees
Wind Speed (Avg Monthly)	0	1	1	1	1	2	2	1	1	1	0	0	m/s
Ground Temperature (Avg Monthly of 3 Depths)	9	10	11	12	15	17	17	17	16	14	11	10	degrees C

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 3, CA, USA
	Latitude/Longitude:	37.7° North, 122.2° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00003 724930 WMO Station Number, **Elevation** 2 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	273	344	429	555	562	566	557	588	498	402	296	272	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	361	424	448	591	556	557	534	598	548	485	401	411	Wh/sq.m
Diffuse Radiation (Avg Hourly)	118	131	167	161	161	156	161	158	143	134	116	108	Wh/sq.m
Global Horiz Radiation (Max Hourly)	540	693	839	934	972	976	973	949	872	748	575	461	Wh/sq.m
Direct Normal Radiation (Max Hourly)	844	873	899	900	896	877	868	863	847	842	813	809	Wh/sq.m
Diffuse Radiation (Max Hourly)	844	873	899	900	896	877	868	863	847	842	813	809	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2097	3162	4285	6226	6966	7404	7209	6581	5295	3753	2479	2027	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	3054	4150	4656	6855	6975	7354	6930	6755	5884	4600	3504	3117	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	928	1220	1701	1845	2032	2067	2107	1831	1566	1293	999	841	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	10	11	12	13	14	16	17	17	17	16	12	10	degrees C
Dew Point Temperature (Avg Monthly)	6	6	7	8	10	11	12	12	12	10	7	6	degrees C
Relative Humidity (Avg Monthly)	80	73	70	73	75	75	77	74	72	72	72	78	percent
Wind Direction (Monthly Mode)	170	150	270	270	270	270	270	300	290	270	140	90	degrees
Wind Speed (Avg Monthly)	3	4	4	4	4	4	4	4	4	3	2	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	11	11	11	12	13	15	16	16	16	15	13	12	degrees C

WEATHER DATA SUMMARY		
	LOCATION:	**Climate Zone 4, CA, USA**
	Latitude/Longitude:	37.4° North, 122.4° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00004 724945 WMO Station Number, **Elevation** 30 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	301	358	461	534	588	586	599	618	521	418	320	267	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	394	447	515	548	604	606	623	660	564	487	408	347	Wh/sq.m
Diffuse Radiation (Avg Hourly)	135	138	161	168	154	148	139	145	152	151	132	126	Wh/sq.m
Global Horiz Radiation (Max Hourly)	566	689	821	940	971	977	974	951	865	755	579	473	Wh/sq.m
Direct Normal Radiation (Max Hourly)	847	868	904	916	891	875	868	863	842	849	814	809	Wh/sq.m
Diffuse Radiation (Max Hourly)	847	868	904	916	891	875	868	863	842	849	814	809	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2325	3290	4628	5980	7256	7671	7715	6928	5521	3907	2662	1999	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	3322	4419	5495	6324	7516	8011	8051	7491	6006	4616	3486	2643	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1067	1277	1637	1926	1953	1964	1815	1697	1659	1462	1140	974	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	9	11	12	14	16	18	19	20	19	16	11	9	degrees C
Dew Point Temperature (Avg Monthly)	4	5	6	7	11	13	15	14	13	11	5	3	degrees C
Relative Humidity (Avg Monthly)	73	72	66	67	73	70	75	72	72	72	68	66	percent
Wind Direction (Monthly Mode)	270	270	140	340	340	340	340	340	340	340	140	150	degrees
Wind Speed (Avg Monthly)	2	3	2	3	2	3	2	3	2	2	2	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	11	11	12	13	16	17	18	17	16	14	13	11	degrees C

WEATHER DATA SUMMARY	
LOCATION:	**Climate Zone 5, CA, USA**
Latitude/Longitude:	34.9° North, 120.4° West, **Time Zone from Greenwich** -8
Data Source:	WYEC2-C-00005 723940 WMO Station Number, **Elevation** 72 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	324	378	490	541	543	578	603	595	502	459	341	330	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	469	438	532	536	461	570	598	596	512	567	492	499	Wh/sq.m
Diffuse Radiation (Avg Hourly)	111	142	156	171	197	151	148	159	151	133	112	113	Wh/sq.m
Global Horiz Radiation (Max Hourly)	574	761	886	972	1077	1030	1008	973	895	791	638	520	Wh/sq.m
Direct Normal Radiation (Max Hourly)	875	949	955	928	936	894	912	883	901	868	853	842	Wh/sq.m
Diffuse Radiation (Max Hourly)	875	949	955	928	936	894	912	883	901	868	853	842	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2659	3472	4887	6055	6444	7549	7468	6649	5324	4307	3020	2530	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	4191	4132	5505	6121	5607	7502	7466	6788	5479	5472	4597	4191	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	941	1325	1600	1953	2367	1989	1857	1827	1644	1304	1018	905	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	11	12	12	13	14	15	16	17	17	15	12	11	degrees C
Dew Point Temperature (Avg Monthly)	4	7	8	8	9	12	11	12	12	11	7	6	degrees C
Relative Humidity (Avg Monthly)	67	72	77	73	72	80	74	79	75	79	71	74	percent
Wind Direction (Monthly Mode)	290	140	290	290	290	300	270	290	290	290	290	290	degrees
Wind Speed (Avg Monthly)	2	3	3	3	3	4	2	3	2	2	3	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	11	11	12	13	14	15	16	15	15	14	13	12	degrees C

WEATHER DATA SUMMARY		
	LOCATION:	**Climate Zone 6, CA, USA**
	Latitude/Longitude:	33.9° North, 118.5° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00006 722970 WMO Station Number, **Elevation** 30 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	352	419	514	535	576	512	591	596	521	436	346	347	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	551	533	583	531	501	437	570	601	541	477	464	524	Wh/sq.m
Diffuse Radiation (Avg Hourly)	102	136	153	175	205	196	166	160	155	160	123	115	Wh/sq.m
Global Horiz Radiation (Max Hourly)	603	753	872	955	993	994	986	961	901	772	651	527	Wh/sq.m
Direct Normal Radiation (Max Hourly)	858	890	904	907	889	877	867	859	851	849	827	832	Wh/sq.m
Diffuse Radiation (Max Hourly)	858	890	904	907	889	877	867	859	851	849	827	832	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2974	3879	5179	6021	6725	6709	7233	6694	5554	4115	3146	2689	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	5020	5180	6161	6138	5874	5723	7007	6818	5755	4572	4435	4395	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	893	1290	1583	2005	2455	2590	2083	1851	1713	1574	1142	930	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	13	13	13	15	16	18	19	20	19	18	15	12	degrees C
Dew Point Temperature (Avg Monthly)	6	8	7	7	11	14	14	15	15	12	8	2	degrees C
Relative Humidity (Avg Monthly)	68	73	71	66	73	80	74	74	75	71	64	55	percent
Wind Direction (Monthly Mode)	270	260	250	240	250	250	250	270	250	270	80	50	degrees
Wind Speed (Avg Monthly)	3	2	3	4	3	3	3	2	3	3	3	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	14	13	13	14	15	17	18	18	18	17	15	15	degrees C

WEATHER DATA SUMMARY

LOCATION: Climate Zone 7, CA, USA
Latitude/Longitude: 32.7° North, 117.2° West, **Time Zone from Greenwich** -8
Data Source: WYEC2-C-00007 722900 WMO Station Number, **Elevation** 4 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	347	436	504	539	551	485	578	593	501	460	358	355	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	502	540	553	520	448	370	507	576	474	533	475	536	Wh/sq.m
Diffuse Radiation (Avg Hourly)	118	144	158	179	210	207	192	166	174	146	123	110	Wh/sq.m
Global Horiz Radiation (Max Hourly)	627	735	878	974	998	999	991	963	917	819	678	548	Wh/sq.m
Direct Normal Radiation (Max Hourly)	873	878	909	906	900	871	868	857	854	850	840	843	Wh/sq.m
Diffuse Radiation (Max Hourly)	873	878	909	906	900	871	868	857	854	850	840	843	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	3023	4037	5099	6056	6295	6317	6907	6639	5341	4368	3354	2781	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	4657	5201	5891	5926	5134	4817	6062	6388	5000	5177	4548	4599	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1053	1366	1634	2063	2469	2728	2356	1927	1921	1456	1195	902	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	13	13	14	15	16	18	20	21	20	18	15	13	degrees C
Dew Point Temperature (Avg Monthly)	4	5	8	9	9	13	17	16	15	10	8	7	degrees C
Relative Humidity (Avg Monthly)	57	63	68	70	65	73	79	72	72	61	65	68	percent
Wind Direction (Monthly Mode)	350	310	290	290	290	290	300	290	200	310	300	20	degrees
Wind Speed (Avg Monthly)	3	2	3	3	3	3	3	3	3	3	3	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	14	14	15	15	17	18	19	18	18	16	15	14	degrees C

WEATHER DATA SUMMARY

LOCATION: **Climate Zone 8, CA, USA**
Latitude/Longitude: 33.6° North, 117.7° West, **Time Zone from Greenwich** -8
Data Source: WYEC2-C-00008 690140 WMO Station Number, **Elevation** 117 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	369	419	507	539	574	536	612	604	507	458	357	354	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	577	553	578	524	497	494	600	593	505	523	495	525	Wh/sq.m
Diffuse Radiation (Avg Hourly)	110	126	153	186	205	171	160	162	165	152	117	118	Wh/sq.m
Global Horiz Radiation (Max Hourly)	613	762	868	957	994	996	990	966	906	767	631	541	Wh/sq.m
Direct Normal Radiation (Max Hourly)	867	890	909	898	883	876	867	856	845	832	826	834	Wh/sq.m
Diffuse Radiation (Max Hourly)	867	890	909	898	883	876	867	856	845	832	826	834	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	3133	3888	5130	6063	6666	7018	7472	6761	5424	4336	3279	2752	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	5246	5367	6239	6044	5767	6466	7373	6633	5396	5024	4689	4433	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	965	1197	1578	2141	2453	2271	2009	1885	1834	1510	1115	952	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	12	13	14	16	17	19	21	21	21	18	15	13	degrees C
Dew Point Temperature (Avg Monthly)	3	6	7	6	11	15	15	15	11	13	8	2	degrees C
Relative Humidity (Avg Monthly)	55	68	68	58	70	76	69	72	57	74	67	51	percent
Wind Direction (Monthly Mode)	90	90	270	50	270	270	270	290	270	290	270	50	degrees
Wind Speed (Avg Monthly)	1	2	2	2	2	2	2	2	1	2	2	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	14	14	15	15	18	19	19	19	18	16	15	14	degrees C

WEATHER DATA SUMMARY	
LOCATION:	**Climate Zone 9, CA, USA**
Latitude/Longitude:	34.15° North, 118.15° West, **Time Zone from Greenwich** -8
Data Source:	WYEC2-C-00009 722880 WMO Station Number, **Elevation** 263 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	419	505	516	491	484	484	612	535	508	453	329	366	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	636	710	546	438	401	419	587	501	512	521	437	551	Wh/sq.m
Diffuse Radiation (Avg Hourly)	126	128	174	190	190	170	175	177	166	144	109	117	Wh/sq.m
Global Horiz Radiation (Max Hourly)	728	874	965	1013	1024	1056	945	931	922	827	724	644	Wh/sq.m
Direct Normal Radiation (Max Hourly)	1061	1093	1089	965	927	918	783	852	876	926	916	1049	Wh/sq.m
Diffuse Radiation (Max Hourly)	1061	1093	1089	965	927	918	783	852	876	926	916	1049	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	3506	4681	5187	5519	5739	6345	7528	6016	5478	4301	2958	2844	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	5668	6940	5651	5078	4973	5552	7280	5794	5791	5135	4143	4745	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1088	1213	1799	2176	2290	2253	2204	2031	1819	1416	1009	941	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	13	13	14	16	18	20	23	22	22	19	15	13	degrees C
Dew Point Temperature (Avg Monthly)	3	3	5	8	10	12	13	15	13	9	6	4	degrees C
Relative Humidity (Avg Monthly)	56	53	58	65	64	66	57	68	62	57	63	59	percent
Wind Direction (Monthly Mode)	340	110	160	180	180	180	180	180	180	160	110	110	degrees
Wind Speed (Avg Monthly)	1	2	3	1	2	2	3	3	1	2	2	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	14	14	15	16	18	19	20	20	19	17	15	14	degrees C

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 10, CA, USA
	Latitude/Longitude:	33.88° North, 117.27° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00010 722860 WMO Station Number, **Elevation** 469 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	399	534	566	511	521	490	591	548	515	436	324	422	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	586	777	636	479	417	402	537	489	531	451	438	712	Wh/sq.m
Diffuse Radiation (Avg Hourly)	130	125	168	186	213	190	188	199	162	164	102	101	Wh/sq.m
Global Horiz Radiation (Max Hourly)	745	875	960	1014	1052	1059	948	926	899	789	665	651	Wh/sq.m
Direct Normal Radiation (Max Hourly)	1058	1097	1092	1001	954	925	782	840	891	870	915	1055	Wh/sq.m
Diffuse Radiation (Max Hourly)	1058	1097	1092	1001	954	925	782	840	891	870	915	1055	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	3377	4957	5674	5777	6091	6430	7264	6208	5538	4166	2986	3314	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	5247	7588	6510	5615	4966	5349	6674	5724	5963	4479	4254	6230	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1126	1194	1741	2139	2550	2516	2367	2304	1770	1618	978	821	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	12	13	13	15	18	21	24	24	22	19	14	11	degrees C
Dew Point Temperature (Avg Monthly)	5	1	4	8	9	11	13	11	9	4	5	-1	degrees C
Relative Humidity (Avg Monthly)	68	50	59	66	59	59	55	49	50	43	60	45	percent
Wind Direction (Monthly Mode)	90	340	250	250	270	270	250	250	270	250	110	90	degrees
Wind Speed (Avg Monthly)	0	3	2	1	2	2	1	1	1	1	0	1	m/s
Ground Temperature (Avg Monthly of 3 Depths)	13	12	13	13	16	18	20	21	21	19	17	15	degrees C

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 11, CA, USA
	Latitude/Longitude:	40.2° North, 122.2° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00011 725910 WMO Station Number, **Elevation** 104 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	242	305	417	546	578	610	646	647	549	422	291	210	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	338	403	473	593	618	649	745	757	721	604	428	299	Wh/sq.m
Diffuse Radiation (Avg Hourly)	108	115	152	165	160	159	135	130	108	108	105	99	Wh/sq.m
Global Horiz Radiation (Max Hourly)	497	690	830	968	1013	1022	1018	986	898	752	585	437	Wh/sq.m
Direct Normal Radiation (Max Hourly)	851	946	962	996	1022	942	933	937	948	945	893	818	Wh/sq.m
Diffuse Radiation (Max Hourly)	851	946	962	996	1022	942	933	937	948	945	893	818	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	1795	2731	4157	6156	7372	8016	8469	7409	5850	3946	2322	1553	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2587	3868	4934	6992	8206	8831	10020	8917	7883	5852	3491	2350	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	833	1042	1538	1893	2072	2119	1800	1562	1202	1054	882	751	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	7	9	11	14	19	23	25	24	21	17	11	7	degrees C
Dew Point Temperature (Avg Monthly)	2	1	4	3	5	6	6	7	5	3	2	1	degrees C
Relative Humidity (Avg Monthly)	75	62	66	51	44	38	34	38	39	44	61	72	percent
Wind Direction (Monthly Mode)	330	160	160	340	170	160	170	170	160	340	340	340	degrees
Wind Speed (Avg Monthly)	3	5	3	4	3	4	3	3	3	4	4	4	m/s
Ground Temperature (Avg Monthly of 3 Depths)	10	9	10	11	14	18	20	21	21	19	16	13	degrees C

WEATHER DATA SUMMARY

LOCATION: Climate Zone 12, CA, USA
Latitude/Longitude: 38.5° North, 121.5° West, **Time Zone from Greenwich** -8
Data Source: WYEC2-C-00012 724830 WMO Station Number, **Elevation** 5 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	264	310	457	563	600	641	648	668	569	435	328	236	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	335	389	531	607	655	700	730	763	725	603	493	309	Wh/sq.m
Diffuse Radiation (Avg Hourly)	126	122	145	169	154	158	145	140	117	111	109	115	Wh/sq.m
Global Horiz Radiation (Max Hourly)	524	715	888	983	1021	1029	1025	996	913	783	597	468	Wh/sq.m
Direct Normal Radiation (Max Hourly)	866	926	958	961	961	941	902	910	919	917	899	837	Wh/sq.m
Diffuse Radiation (Max Hourly)	866	926	958	961	961	941	902	910	919	917	899	837	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	1972	2825	4573	6350	7553	8424	8487	7544	6082	4093	2715	1751	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2577	3786	5586	7117	8565	9509	9745	8894	7954	5882	4233	2324	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	972	1125	1491	1947	1976	2105	1922	1644	1301	1087	947	877	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	7	10	12	14	18	21	22	22	20	16	11	7	degrees C
Dew Point Temperature (Avg Monthly)	4	5	5	7	8	10	11	11	9	8	4	4	degrees C
Relative Humidity (Avg Monthly)	82	74	67	66	59	53	53	54	54	59	62	80	percent
Wind Direction (Monthly Mode)	330	160	330	330	230	210	220	220	200	180	310	330	degrees
Wind Speed (Avg Monthly)	3	4	4	3	3	4	4	4	3	2	2	3	m/s
Ground Temperature (Avg Monthly of 3 Depths)	9	10	11	13	16	19	20	19	18	15	12	10	degrees C

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 13, CA, USA
	Latitude/Longitude:	36.8° North, 119.7° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00013 723890 WMO Station Number, **Elevation** 100 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	269	354	499	591	640	653	664	669	595	486	337	236	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	295	424	576	615	698	726	740	747	767	669	473	250	Wh/sq.m
Diffuse Radiation (Avg Hourly)	141	134	157	189	158	141	144	147	106	108	122	136	Wh/sq.m
Global Horiz Radiation (Max Hourly)	571	741	901	1047	1028	1166	1050	1006	926	813	636	509	Wh/sq.m
Direct Normal Radiation (Max Hourly)	844	930	957	1044	960	982	923	923	930	1006	909	854	Wh/sq.m
Diffuse Radiation (Max Hourly)	844	930	957	1044	960	982	923	923	930	1006	909	854	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2113	3257	5012	6667	7891	8576	8534	7564	6382	4588	2871	1799	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2456	4022	6121	7284	9044	9804	9890	8709	8455	6480	4214	2004	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1134	1260	1615	2170	1985	1888	1884	1742	1193	1090	1081	1055	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	8	11	13	16	21	25	28	26	23	18	11	8	degrees C
Dew Point Temperature (Avg Monthly)	4	6	6	7	6	8	10	13	9	7	7	5	degrees C
Relative Humidity (Avg Monthly)	80	75	68	57	44	37	36	45	45	52	77	82	percent
Wind Direction (Monthly Mode)	120	110	310	320	310	290	320	300	310	310	300	120	degrees
Wind Speed (Avg Monthly)	2	2	3	3	3	3	2	2	2	2	1	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	10	11	13	15	19	22	23	23	21	17	14	11	degrees C

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 14, CA, USA
	Latitude/Longitude:	35.7° North, 117.7° West, **Time Zone from Greenwich** -8
	Data Source:	WYEC2-C-00014 C00001 WMO Station Number, **Elevation** 699 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	349	441	530	627	661	660	655	671	588	484	367	346	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	526	626	634	748	742	757	740	766	728	624	516	564	Wh/sq.m
Diffuse Radiation (Avg Hourly)	116	122	146	130	137	130	130	128	117	127	122	104	Wh/sq.m
Global Horiz Radiation (Max Hourly)	573	731	911	1007	1036	1040	1030	1007	937	811	662	527	Wh/sq.m
Direct Normal Radiation (Max Hourly)	872	967	977	1010	1002	995	967	947	954	966	894	864	Wh/sq.m
Diffuse Radiation (Max Hourly)	872	967	977	1010	1002	995	967	947	954	966	894	864	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	2812	4083	5334	7113	8074	8690	8312	7606	6339	4636	3240	2666	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	4390	6056	6651	8923	9485	10250	9562	8976	8043	6236	4784	4400	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	984	1157	1519	1508	1732	1744	1709	1523	1333	1276	1124	873	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	6	9	11	14	19	24	28	27	23	17	10	6	degrees C
Dew Point Temperature (Avg Monthly)	-5	-5	-3	-6	-3	-2	0	0	1	-5	-3	-5	degrees C
Relative Humidity (Avg Monthly)	45	36	37	26	25	19	16	17	25	21	41	44	percent
Wind Direction (Monthly Mode)	210	230	230	270	230	270	230	230	230	230	230	340	degrees
Wind Speed (Avg Monthly)	1	2	4	3	3	5	3	2	3	2	2	1	m/s
Ground Temperature (Avg Monthly of 3 Depths)	8	9	11	13	18	21	23	22	20	16	12	10	degrees C

WEATHER DATA SUMMARY

LOCATION: Climate Zone 15, CA, USA
Latitude/Longitude: 32.8° North, 115.6° West, **Time Zone from Greenwich** -8
Data Source: WYEC2-C-00015 747185 WMO Station Number, **Elevation** -9 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	425	464	566	620	589	626	571	600	559	504	382	371	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	641	586	655	666	542	644	495	565	596	622	554	587	Wh/sq.m
Diffuse Radiation (Avg Hourly)	129	152	151	154	174	139	197	188	154	125	100	109	Wh/sq.m
Global Horiz Radiation (Max Hourly)	764	893	995	1022	1034	1034	990	935	883	803	682	661	Wh/sq.m
Direct Normal Radiation (Max Hourly)	1057	1117	1172	1056	1011	953	844	820	853	929	945	1051	Wh/sq.m
Diffuse Radiation (Max Hourly)	1057	1117	1172	1056	1011	953	844	820	853	929	945	1051	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	3744	4354	5755	7054	6889	8273	6890	6826	6120	4934	3640	2961	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	6090	5826	6977	7865	6724	8777	6135	6606	6993	6621	5529	5197	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	1150	1464	1596	1804	2098	1878	2430	2203	1712	1252	1000	908	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	13	15	18	22	26	31	33	33	30	24	16	13	degrees C
Dew Point Temperature (Avg Monthly)	0	-1	-6	2	2	2	11	10	3	0	2	-4	degrees C
Relative Humidity (Avg Monthly)	45	33	21	31	27	18	29	27	19	22	42	30	percent
Wind Direction (Monthly Mode)	0	340	340	160	160	160	160	160	160	340	340	0	degrees
Wind Speed (Avg Monthly)	2	3	4	3	3	3	4	3	2	2	2	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	15	16	18	20	25	28	29	28	26	23	19	17	degrees C

WEATHER DATA SUMMARY	LOCATION:	Climate Zone 16, CA, USA
	Latitude/Longitude:	41.3° North, 122.3° West, **Time Zone from Greenwich** -8
	Data Source:	CTZRV2 725957 WMO Station Number, **Elevation** 1080 m

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	238	286	412	499	537	595	627	607	529	394	239	224	Wh/sq.m
Direct Normal Radiation (Avg Hourly)	307	351	405	511	518	605	718	683	658	518	294	291	Wh/sq.m
Diffuse Radiation (Avg Hourly)	121	127	186	175	188	166	126	143	124	128	121	122	Wh/sq.m
Global Horiz Radiation (Max Hourly)	504	630	844	945	994	1004	1002	966	875	722	555	422	Wh/sq.m
Direct Normal Radiation (Max Hourly)	890	921	976	973	957	929	918	928	902	879	856	818	Wh/sq.m
Diffuse Radiation (Max Hourly)	890	921	976	973	957	929	918	928	902	879	856	818	Wh/sq.m
Global Horiz Radiation (Avg Daily Total)	1795	2521	4128	5610	6934	7823	8205	7046	5633	3685	1891	1664	Wh/sq.m
Direct Normal Radiation (Avg Daily Total)	2596	3292	4329	5878	6842	7974	9441	7986	7094	4875	2460	2305	Wh/sq.m
Diffuse Radiation (Avg Daily Total)	923	1141	1888	2009	2455	2230	1680	1729	1375	1247	978	921	Wh/sq.m
Global Horiz Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Direct Normal Illumination (Avg Hourly)	0	0	0	0	0	0	0	0	0	0	0	0	lux
Dry Bulb Temperature (Avg Monthly)	2	3	6	8	13	16	20	19	15	9	5	1	degrees C
Dew Point Temperature (Avg Monthly)	-1	0	0	0	3	7	8	5	4	1	1	-1	degrees C
Relative Humidity (Avg Monthly)	74	75	62	59	51	54	47	43	49	59	76	77	percent
Wind Direction (Monthly Mode)	130	140	140	320	160	340	350	160	320	320	160	330	degrees
Wind Speed (Avg Monthly)	3	3	3	4	3	5	2	2	3	3	3	2	m/s
Ground Temperature (Avg Monthly of 3 Depths)	4	3	4	5	8	12	14	16	15	13	10	7	degrees C

Appendix B: Generalized Simulation Data

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
1	1	LA	Restaurant	38	694.47	297.43	397.04	114.11	1.70	5.79	28.17
2	1	LA	Hospital	7	13,620.02	9,317.17	4,302.85	3,755.07	4,082.92	13,931.48	856.48
3	1	LA	Large Hotel	21	4,728.58	2,554.31	2,174.28	285.99	932.21	3,180.83	303.58
4	1	LA	Large Office	12	5,915.71	5,552.88	362.83	310.17	587.85	2,005.84	126.11
5	1	LA	Medium Office	9	631.99	622.51	9.48	1.23	26.36	89.93	14.33
6	1	LA	Midrise Apartment	36	310.13	210.69	99.43	33.44	9.57	32.66	5.06
7	1	LA	Out Patient Clinic	6	2,090.49	1,203.04	887.45	824.64	230.81	787.55	219.45
8	1	LA	Primary School	3	1,042.08	793.72	248.36	142.51	24.94	85.11	27.82
9	1	LA	Fast Food Restaurant	34	393.34	183.77	209.57	33.05	0.30	1.02	15.44
10	1	LA	Secondary School	3	3,384.06	2,311.92	1,072.14	874.31	347.53	1,185.82	272.86
11	1	LA	Small Hotel	21	750.13	545.13	205.00	59.13	57.59	196.51	53.99
12	1	LA	Small Office	10	65.99	60.13	5.86	2.84	1.27	4.32	8.70
13	1	LA	Retail - Stand Alone	16	386.30	291.66	94.64	94.64	1.84	6.27	58.81
14	1	LA	Strip Mall	16	378.09	267.46	110.64	110.64	1.96	6.67	41.20
15	1	LA	Super Market	33	2,239.77	1,604.53	635.24	573.83	0.86	2.93	117.07
16	1	LA	Warehouse	1	353.31	232.11	121.21	121.21	0.15	0.52	12.62
17	1	SF	Restaurant	38	708.39	295.84	412.54	122.50	1.10	3.75	27.22
18	1	SF	Hospital	7	13,555.94	8,875.86	4,680.08	4,111.60	3,624.24	12,366.40	920.94
19	1	SF	Large Hotel	21	4,833.65	2,428.18	2,405.47	288.23	789.71	2,694.59	319.76
20	1	SF	Large Office	13	6,422.90	5,608.43	814.47	754.05	621.99	2,122.32	143.26
21	1	SF	Medium Office	9	687.10	677.57	9.53	0.37	31.12	106.19	16.86
22	1	SF	Midrise Apartment	36	323.52	214.25	109.27	33.58	11.88	40.55	6.30
23	1	SF	Out Patient Clinic	6	2,131.83	1,216.58	915.25	851.20	229.06	781.57	221.99
24	1	SF	Primary School	3	1,154.53	809.97	344.55	233.67	32.29	110.19	36.59
25	1	SF	Fast Food Restaurant	34	398.79	184.34	214.45	35.79	0.26	0.87	16.09
26	1	SF	Secondary School	4	3,712.66	2,436.08	1,276.58	1,064.86	453.39	1,547.03	290.54
27	1	SF	Small Hotel	21	765.01	544.84	220.17	62.90	57.78	197.16	53.46
28	1	SF	Small Office	10	67.45	59.98	7.47	4.35	1.04	3.54	8.78
29	1	SF	Retail - Stand Alone	16	398.66	263.86	134.81	134.81	1.31	4.47	31.35
30	1	SF	Strip Mall	16	394.03	261.53	132.49	132.49	0.93	3.17	36.30
31	1	SF	Super Market	33	2,305.70	1,611.16	694.54	632.68	0.63	2.15	123.99
32	1	SF	Warehouse	1	357.59	233.16	124.43	124.43	0.14	0.49	13.68

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
33	2	LA	Restaurant	37	705.49	311.41	394.08	111.15	15.39	52.52	28.23
34	2	LA	Hospital	7	13,313.51	9,196.43	4,117.09	3,569.31	3,908.77	13,337.27	863.15
35	2	LA	Large Hotel	20	4,826.94	2,667.03	2,159.91	271.62	1,041.87	3,555.01	304.17
36	2	LA	Large Office	14	6,210.67	5,878.77	331.90	279.25	864.39	2,949.43	139.78
37	2	LA	Medium Office	9	667.10	654.24	12.87	4.61	60.76	207.32	16.09
38	2	LA	Midrise Apartment	30	331.57	227.86	103.71	37.72	23.56	80.40	8.21
39	2	LA	Out Patient Clinic	6	2,100.32	1,249.90	850.42	787.61	266.81	910.39	222.02
40	2	LA	Primary School	3	1,090.36	845.95	244.41	138.56	72.64	247.84	31.86
41	2	LA	Fast Food Restaurant	35	402.56	189.63	212.93	36.41	5.86	20.00	15.43
42	2	LA	Secondary School	5	3,798.69	2,778.83	1,019.86	822.03	799.06	2,726.49	285.30
43	2	LA	Small Hotel	22	772.35	568.37	203.98	58.10	79.19	270.22	55.48
44	2	LA	Small Office	10	68.84	62.55	6.29	3.27	3.63	12.39	8.75
45	2	LA	Retail - Stand Alone	15	407.57	310.43	97.14	97.14	20.64	70.44	58.82
46	2	LA	Strip Mall	15	399.84	285.51	114.33	114.33	20.08	68.51	41.09
47	2	LA	Super Market	33	2,179.51	1,607.99	571.53	510.11	17.64	60.21	117.57
48	2	LA	Warehouse	1	364.37	235.41	128.96	128.96	3.08	10.49	12.97
49	2	SF	Restaurant	37	716.67	309.05	407.62	117.58	14.03	47.87	27.26
50	2	SF	Hospital	7	13,227.34	8,796.92	4,430.42	3,861.94	3,483.21	11,885.21	928.85
51	2	SF	Large Hotel	21	4,842.01	2,454.15	2,387.86	270.62	811.60	2,769.29	320.80
52	2	SF	Large Office	12	6,624.60	5,928.63	695.97	635.54	884.82	3,019.13	162.65
53	2	SF	Medium Office	9	721.87	710.37	11.51	2.35	72.24	246.48	19.44
54	2	SF	Midrise Apartment	30	349.08	235.20	113.88	38.19	28.36	96.77	10.76
55	2	SF	Out Patient Clinic	6	2,124.13	1,263.12	861.01	796.96	264.73	903.28	224.97
56	2	SF	Primary School	3	1,209.24	867.09	342.15	231.26	85.57	291.97	39.87
57	2	SF	Fast Food Restaurant	35	407.54	190.09	217.45	38.79	5.69	19.42	16.07
58	2	SF	Secondary School	5	4,211.29	2,996.18	1,215.11	1,003.39	1,000.61	3,414.23	300.17
59	2	SF	Small Hotel	22	789.86	571.28	218.57	61.31	82.06	279.99	55.40
60	2	SF	Small Office	10	70.54	62.49	8.04	4.93	3.57	12.18	8.76
61	2	SF	Retail - Stand Alone	16	406.49	276.97	129.52	129.52	14.41	49.18	31.38
62	2	SF	Strip Mall	16	409.39	276.49	132.91	132.91	16.01	54.63	36.14
63	2	SF	Super Market	33	2,217.61	1,610.86	606.75	544.89	13.91	47.48	124.70
64	2	SF	Warehouse	1	370.05	236.41	133.63	133.63	3.01	10.27	14.04

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
65	3	LA	Restaurant	38	662.68	302.59	360.09	77.16	6.69	22.81	28.06
66	3	LA	Hospital	7	13,461.44	9,335.76	4,125.68	3,577.90	4,076.74	13,910.42	860.13
67	3	LA	Large Hotel	21	4,781.61	2,698.93	2,082.68	194.39	1,075.66	3,670.31	303.55
68	3	LA	Large Office	13	6,159.15	5,933.15	226.00	173.35	909.52	3,103.41	132.12
69	3	LA	Medium Office	10	635.88	627.03	8.85	0.59	50.51	172.35	14.97
70	3	LA	Midrise Apartment	36	304.65	220.53	84.12	18.13	18.24	62.24	6.20
71	3	LA	Out Patient Clinic	6	2,086.12	1,233.13	852.99	790.18	266.48	909.25	219.41
72	3	LA	Primary School	3	1,026.91	827.91	198.99	93.14	56.08	191.35	30.55
73	3	LA	Fast Food Restaurant	34	383.24	185.71	197.53	21.01	1.95	6.64	15.36
74	3	LA	Secondary School	4	3,404.45	2,629.72	774.74	576.90	656.18	2,238.99	279.90
75	3	LA	Small Hotel	21	751.40	563.92	187.48	41.61	75.17	256.49	55.25
76	3	LA	Small Office	10	65.94	61.55	4.39	1.37	2.70	9.20	8.68
77	3	LA	Retail - Stand Alone	16	363.06	298.38	64.68	64.68	9.22	31.47	58.41
78	3	LA	Strip Mall	16	353.64	274.43	79.21	79.21	9.31	31.76	40.78
79	3	LA	Super Market	33	2,145.16	1,637.01	508.15	446.74	5.68	19.39	116.86
80	3	LA	Warehouse	1	326.09	232.09	94.00	94.00	0.65	2.22	12.07
81	3	SF	Restaurant	38	672.74	300.23	372.52	82.47	5.33	18.17	27.08
82	3	SF	Hospital	7	13,238.23	8,827.72	4,410.51	3,842.04	3,552.01	12,119.97	923.54
83	3	SF	Large Hotel	21	4,800.38	2,498.75	2,301.63	184.40	858.64	2,929.79	319.93
84	3	SF	Large Office	13	6,552.89	6,001.53	551.37	490.95	951.17	3,245.51	151.25
85	3	SF	Medium Office	9	683.19	673.88	9.31	0.15	59.65	203.53	17.88
86	3	SF	Midrise Apartment	36	320.36	227.05	93.31	17.63	22.39	76.39	8.58
87	3	SF	Out Patient Clinic	6	2,104.72	1,240.94	863.78	799.73	263.26	898.29	221.61
88	3	SF	Primary School	3	1,111.85	847.18	264.67	153.79	67.70	231.01	38.13
89	3	SF	Fast Food Restaurant	34	387.32	186.12	201.20	22.54	1.75	5.96	16.00
90	3	SF	Secondary School	5	3,717.60	2,817.58	900.02	688.29	830.13	2,832.50	293.25
91	3	SF	Small Hotel	21	767.52	566.31	201.21	43.94	77.69	265.10	55.10
92	3	SF	Small Office	10	66.56	61.28	5.28	2.16	2.49	8.48	8.63
93	3	SF	Retail - Stand Alone	16	360.98	267.70	93.28	93.28	5.68	19.37	31.16
94	3	SF	Strip Mall	16	361.09	266.38	94.71	94.71	6.22	21.23	35.81
95	3	SF	Super Market	33	2,188.66	1,642.33	546.33	484.47	4.37	14.92	123.78
96	3	SF	Warehouse	1	329.33	233.08	96.25	96.25	0.63	2.14	13.09

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
97	4	LA	Restaurant	37	677.50	312.15	365.34	82.41	16.03	54.70	28.15
98	4	LA	Hospital	7	13,211.80	9,207.05	4,004.75	3,456.97	3,911.79	13,347.57	863.59
99	4	LA	Large Hotel	21	4,811.56	2,721.53	2,090.03	201.74	1,095.90	3,739.35	304.13
100	4	LA	Large Office	12	6,307.07	6,071.79	235.28	182.63	1,029.30	3,512.11	138.73
101	4	LA	Medium Office	9	665.07	654.96	10.12	1.86	75.95	259.16	15.88
102	4	LA	Midrise Apartment	27	321.16	232.16	89.01	23.02	27.64	94.30	8.44
103	4	LA	Out Patient Clinic	6	2,074.47	1,265.46	809.01	746.20	289.29	987.10	220.99
104	4	LA	Primary School	3	1,069.29	862.70	206.60	100.75	88.87	303.24	32.27
105	4	LA	Fast Food Restaurant	35	391.33	189.71	201.63	25.11	5.74	19.57	15.38
106	4	LA	Secondary School	5	3,658.86	2,864.20	794.66	596.83	883.08	3,013.19	285.30
107	4	LA	Small Hotel	22	770.41	579.83	190.58	44.71	90.03	307.20	56.26
108	4	LA	Small Office	10	67.90	63.11	4.80	1.77	4.23	14.42	8.71
109	4	LA	Retail - Stand Alone	16	382.06	311.75	70.31	70.31	22.41	76.46	58.59
110	4	LA	Strip Mall	15	371.54	287.06	84.49	84.49	21.84	74.52	40.88
111	4	LA	Super Market	17	2,155.37	1,665.35	490.02	428.61	16.03	54.71	117.25
112	4	LA	Warehouse	1	338.74	234.26	104.49	104.49	2.48	8.47	12.41
113	4	SF	Restaurant	37	686.00	308.84	377.16	87.11	13.72	46.80	27.17
114	4	SF	Hospital	8	13,001.51	8,751.95	4,249.55	3,681.08	3,435.35	11,721.90	928.20
115	4	SF	Large Hotel	21	4,803.71	2,494.01	2,309.70	192.47	850.90	2,903.38	320.74
116	4	SF	Large Office	12	6,642.48	6,123.33	519.14	458.72	1,053.28	3,593.94	159.66
117	4	SF	Medium Office	9	712.63	702.59	10.03	0.87	88.81	303.02	18.98
118	4	SF	Midrise Apartment	27	338.21	240.03	98.18	22.49	32.55	111.06	11.40
119	4	SF	Out Patient Clinic	6	2,079.18	1,271.97	807.21	743.15	284.39	970.38	223.49
120	4	SF	Primary School	3	1,159.03	883.94	275.09	164.21	103.04	351.57	39.24
121	4	SF	Fast Food Restaurant	35	395.11	189.77	205.34	26.68	5.18	17.69	16.02
122	4	SF	Secondary School	5	3,994.39	3,070.03	924.37	712.64	1,076.03	3,671.56	297.57
123	4	SF	Small Hotel	22	787.29	583.12	204.18	46.91	93.28	318.30	56.27
124	4	SF	Small Office	10	68.71	62.86	5.86	2.74	4.03	13.73	8.67
125	4	SF	Retail - Stand Alone	16	371.78	276.33	95.45	95.45	14.21	48.48	31.25
126	4	SF	Strip Mall	15	374.66	276.46	98.21	98.21	16.22	55.33	35.90
127	4	SF	Super Market	17	2,183.17	1,667.95	515.22	453.36	12.16	41.49	124.27
128	4	SF	Warehouse	1	342.79	235.20	107.59	107.59	2.39	8.17	13.44

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
129	5	LA	Restaurant	38	662.94	303.49	359.46	76.53	8.14	27.79	27.45
130	5	LA	Hospital	7	13,298.26	9,260.51	4,037.75	3,489.97	3,987.23	13,605.00	861.93
131	5	LA	Large Hotel	23	4,810.79	2,736.76	2,074.04	185.75	1,112.76	3,796.89	303.79
132	5	LA	Large Office	13	6,257.01	6,063.12	193.89	141.23	1,020.60	3,482.44	134.27
133	5	LA	Medium Office	9	637.88	628.68	9.20	0.94	56.67	193.36	15.12
134	5	LA	Midrise Apartment	36	302.54	221.40	81.14	15.15	19.08	65.10	6.23
135	5	LA	Out Patient Clinic	6	2,087.69	1,245.47	842.22	779.41	276.08	942.03	220.35
136	5	LA	Primary School	3	1,025.93	835.99	189.94	84.09	63.29	215.94	31.35
137	5	LA	Fast Food Restaurant	34	385.15	186.41	198.74	22.23	2.55	8.69	15.39
138	5	LA	Secondary School	4	3,421.94	2,746.80	675.14	477.31	770.97	2,630.66	281.72
139	5	LA	Small Hotel	23	759.59	569.27	190.33	44.45	80.06	273.17	55.69
140	5	LA	Small Office	10	65.83	61.86	3.97	0.94	2.94	10.03	8.75
141	5	LA	Retail - Stand Alone	16	355.06	300.06	54.99	54.99	10.81	36.87	58.58
142	5	LA	Strip Mall	16	345.74	276.01	69.74	69.74	10.84	36.99	40.80
143	5	LA	Super Market	33	2,111.48	1,643.09	468.38	406.97	6.83	23.32	117.79
144	5	LA	Warehouse	1	322.48	232.19	90.29	90.29	0.61	2.09	12.20
145	5	SF	Restaurant	38	673.87	301.86	372.02	81.97	6.79	23.18	27.19
146	5	SF	Hospital	7	13,060.01	8,774.16	4,285.86	3,717.38	3,484.11	11,888.28	924.53
147	5	SF	Large Hotel	21	4,800.35	2,507.42	2,292.93	175.69	866.72	2,957.38	319.89
148	5	SF	Large Office	13	6,612.68	6,130.48	482.20	421.77	1,059.13	3,613.91	154.17
149	5	SF	Medium Office	9	684.52	674.94	9.58	0.43	67.61	230.71	18.17
150	5	SF	Midrise Apartment	36	318.68	228.63	90.06	14.37	23.71	80.91	8.82
151	5	SF	Out Patient Clinic	6	2,101.95	1,252.67	849.28	785.22	273.06	931.70	222.71
152	5	SF	Primary School	3	1,108.56	857.11	251.45	140.56	76.84	262.20	38.84
153	5	SF	Fast Food Restaurant	34	389.59	186.81	202.79	24.13	2.38	8.10	15.99
154	5	SF	Secondary School	5	3,756.89	2,966.40	790.49	578.77	977.09	3,333.97	294.53
155	5	SF	Small Hotel	23	776.80	572.39	204.41	47.14	83.22	283.96	55.64
156	5	SF	Small Office	10	66.19	61.48	4.71	1.60	2.75	9.37	8.55
157	5	SF	Retail - Stand Alone	16	348.12	268.35	79.77	79.77	6.35	21.68	31.21
158	5	SF	Strip Mall	16	351.68	267.31	84.36	84.36	7.34	25.03	35.61
159	5	SF	Super Market	33	2,151.54	1,648.30	503.24	441.38	5.26	17.96	124.82
160	5	SF	Warehouse	1	326.08	233.19	92.89	92.89	0.59	2.03	13.21

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
161	6	LA	Restaurant	38	631.79	307.02	324.77	41.84	11.47	39.14	27.32
162	6	LA	Hospital	8	13,159.61	9,254.45	3,905.16	3,357.38	3,942.91	13,453.76	864.41
163	6	LA	Large Hotel	21	4,853.24	2,847.14	2,006.10	117.81	1,221.36	4,167.46	304.54
164	6	LA	Large Office	13	6,452.17	6,329.16	123.01	70.36	1,241.91	4,237.57	140.32
165	6	LA	Medium Office	9	646.34	638.00	8.34	0.08	77.53	264.55	15.85
166	6	LA	Midrise Apartment	26	302.70	231.67	71.03	5.04	27.86	95.08	7.73
167	6	LA	Out Patient Clinic	6	2,094.04	1,281.86	812.19	749.38	312.71	1,067.00	219.88
168	6	LA	Primary School	3	1,013.49	859.18	154.31	48.47	84.38	287.93	33.18
169	6	LA	Fast Food Restaurant	34	374.46	187.78	186.68	10.16	3.56	12.16	15.34
170	6	LA	Secondary School	5	3,440.36	2,965.09	475.27	277.44	981.13	3,347.75	287.97
171	6	LA	Small Hotel	23	756.33	585.66	170.68	24.80	95.21	324.87	56.88
172	6	LA	Small Office	10	66.38	63.03	3.35	0.32	4.15	14.17	8.71
173	6	LA	Retail - Stand Alone	16	337.62	304.17	33.46	33.46	15.57	53.13	58.12
174	6	LA	Strip Mall	16	323.54	279.60	43.93	43.93	14.78	50.44	40.50
175	6	LA	Super Market	32	2,064.16	1,689.32	374.84	313.44	10.01	34.16	117.18
176	6	LA	Warehouse	1	294.59	232.18	62.42	62.42	1.29	4.41	11.53
177	6	SF	Restaurant	38	638.88	304.59	334.29	44.24	9.37	31.96	27.01
178	6	SF	Hospital	8	12,773.88	8,700.28	4,073.60	3,505.13	3,373.47	11,510.75	925.82
179	6	SF	Large Hotel	21	4,775.09	2,554.83	2,220.27	103.04	911.95	3,111.71	320.93
180	6	SF	Large Office	13	6,690.07	6,377.90	312.17	251.74	1,265.28	4,317.31	159.74
181	6	SF	Medium Office	9	685.55	676.38	9.18	0.02	91.07	310.73	18.91
182	6	SF	Midrise Apartment	30	320.70	240.24	80.46	4.78	33.04	112.74	11.13
183	6	SF	Out Patient Clinic	6	2,086.14	1,283.52	802.62	738.57	307.34	1,048.67	221.68
184	6	SF	Primary School	3	1,077.03	882.76	194.27	83.38	101.48	346.26	39.66
185	6	SF	Fast Food Restaurant	34	377.47	187.94	189.53	10.87	3.18	10.86	15.91
186	6	SF	Secondary School	5	3,746.98	3,205.42	541.56	329.84	1,212.36	4,136.73	296.53
187	6	SF	Small Hotel	23	772.74	589.70	183.04	25.77	99.14	338.27	57.00
188	6	SF	Small Office	10	66.21	62.54	3.67	0.56	3.91	13.33	8.47
189	6	SF	Retail - Stand Alone	16	319.21	270.59	48.61	48.61	9.11	31.10	30.96
190	6	SF	Strip Mall	16	321.65	269.49	52.16	52.16	9.97	34.01	35.20
191	6	SF	Super Market	32	2,088.94	1,693.11	395.83	333.97	7.56	25.80	124.16
192	6	SF	Warehouse	1	296.88	233.13	63.75	63.75	1.24	4.23	12.54

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
193	7	LA	Restaurant	38	630.13	310.05	320.09	37.16	14.51	49.49	27.22
194	7	LA	Hospital	8	13,113.14	9,227.35	3,885.79	3,338.01	3,929.33	13,407.42	864.79
195	7	LA	Large Hotel	21	4,880.48	2,880.59	1,999.89	111.60	1,253.87	4,278.38	304.64
196	7	LA	Large Office	13	6,521.51	6,408.46	113.05	60.40	1,315.14	4,487.44	141.68
197	7	LA	Medium Office	9	654.63	646.26	8.37	0.11	87.44	298.35	16.07
198	7	LA	Midrise Apartment	30	306.46	236.04	70.42	4.43	31.52	107.54	8.43
199	7	LA	Out Patient Clinic	6	2,080.57	1,285.52	795.04	732.23	322.30	1,099.72	219.08
200	7	LA	Primary School	3	1,021.29	872.26	149.03	43.18	96.63	329.71	33.86
201	7	LA	Fast Food Restaurant	35	375.16	189.11	186.06	9.54	4.82	16.45	15.29
202	7	LA	Secondary School	5	3,502.22	3,060.96	441.26	243.42	1,073.90	3,664.30	290.14
203	7	LA	Small Hotel	23	760.56	591.87	168.70	22.83	101.22	345.37	57.09
204	7	LA	Small Office	10	66.83	63.54	3.29	0.27	4.68	15.95	8.69
205	7	LA	Retail - Stand Alone	16	338.32	308.19	30.13	30.13	19.92	67.97	57.79
206	7	LA	Strip Mall	15	323.32	283.52	39.80	39.80	18.90	64.49	40.26
207	7	LA	Super Market	32	2,051.21	1,700.31	350.90	289.49	13.50	46.05	116.79
208	7	LA	Warehouse	1	290.88	232.97	57.92	57.92	2.19	7.47	11.40
209	7	SF	Restaurant	38	636.43	307.23	329.19	39.14	12.08	41.23	26.85
210	7	SF	Hospital	8	12,712.84	8,673.97	4,038.87	3,470.40	3,363.74	11,477.57	924.56
211	7	SF	Large Hotel	21	4,770.37	2,555.80	2,214.57	97.33	912.11	3,112.25	320.76
212	7	SF	Large Office	13	6,737.84	6,450.81	287.03	226.61	1,332.76	4,547.55	160.79
213	7	SF	Medium Office	9	692.96	683.77	9.19	0.03	101.68	346.94	19.04
214	7	SF	Midrise Apartment	30	324.47	244.61	79.86	4.18	36.57	124.79	11.95
215	7	SF	Out Patient Clinic	6	2,066.18	1,285.47	780.71	716.65	315.78	1,077.49	220.74
216	7	SF	Primary School	3	1,081.70	896.06	185.64	74.76	114.43	390.46	39.84
217	7	SF	Fast Food Restaurant	35	377.89	189.10	188.79	10.13	4.30	14.66	15.84
218	7	SF	Secondary School	5	3,803.31	3,302.57	500.74	289.02	1,307.97	4,462.97	297.13
219	7	SF	Small Hotel	23	776.77	595.91	180.86	23.59	105.11	358.63	57.24
220	7	SF	Small Office	10	66.52	62.92	3.60	0.49	4.37	14.92	8.37
221	7	SF	Retail - Stand Alone	16	316.14	273.32	42.82	42.82	12.04	41.10	30.76
222	7	SF	Strip Mall	16	318.84	272.46	46.38	46.38	13.27	45.29	34.83
223	7	SF	Super Market	32	2,071.45	1,703.08	368.38	306.52	10.07	34.35	123.77
224	7	SF	Warehouse	1	292.59	233.88	58.71	58.71	2.10	7.17	12.40

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
225	8	LA	Restaurant	37	642.78	314.86	327.92	44.99	18.95	64.65	27.59
226	8	LA	Hospital	8	12,956.35	9,169.72	3,786.63	3,238.85	3,844.51	13,118.00	869.31
227	8	LA	Large Hotel	21	4,878.27	2,861.34	2,016.94	128.65	1,233.11	4,207.56	305.68
228	8	LA	Large Office	13	6,529.55	6,407.31	122.24	69.59	1,312.55	4,478.61	147.57
229	8	LA	Medium Office	9	664.62	656.11	8.51	0.25	94.43	322.21	16.95
230	8	LA	Midrise Apartment	30	314.28	241.28	73.01	7.01	35.74	121.96	9.44
231	8	LA	Out Patient Clinic	6	2,087.81	1,305.00	782.82	720.01	331.01	1,129.47	222.99
232	8	LA	Primary School	3	1,043.44	888.01	155.43	49.57	110.56	377.26	35.60
233	8	LA	Fast Food Restaurant	35	380.16	191.45	188.72	12.20	7.02	23.95	15.43
234	8	LA	Secondary School	5	3,631.33	3,155.32	476.01	278.18	1,161.46	3,963.06	296.27
235	8	LA	Small Hotel	23	771.01	598.85	172.16	26.29	107.22	365.86	58.08
236	8	LA	Small Office	10	67.84	64.40	3.44	0.42	5.40	18.43	8.83
237	8	LA	Retail - Stand Alone	16	349.80	315.93	33.88	33.88	26.78	91.37	58.65
238	8	LA	Strip Mall	15	335.01	290.99	44.03	44.03	25.73	87.80	40.90
239	8	LA	Super Market	17	2,054.09	1,701.32	352.77	291.36	19.78	67.48	118.38
240	8	LA	Warehouse	1	300.57	235.16	65.42	65.42	3.92	13.36	11.86
241	8	SF	Restaurant	37	649.69	312.21	337.48	47.43	16.63	56.76	27.28
242	8	SF	Hospital	8	12,596.36	8,654.59	3,941.78	3,373.30	3,308.26	11,288.25	933.28
243	8	SF	Large Hotel	21	4,785.20	2,553.34	2,231.86	114.63	907.39	3,096.14	322.37
244	8	SF	Large Office	13	6,739.61	6,449.99	289.61	229.19	1,327.87	4,530.88	169.27
245	8	SF	Medium Office	9	704.42	695.19	9.23	0.07	110.52	377.11	20.22
246	8	SF	Midrise Apartment	30	333.29	250.94	82.34	6.66	41.53	141.72	13.32
247	8	SF	Out Patient Clinic	6	2,076.29	1,307.16	769.13	705.08	325.86	1,111.87	225.14
248	8	SF	Primary School	3	1,108.29	912.93	195.36	84.48	129.41	441.56	41.65
249	8	SF	Fast Food Restaurant	35	383.06	191.44	191.61	12.95	6.47	22.08	16.00
250	8	SF	Secondary School	5	3,952.38	3,410.60	541.78	330.05	1,410.88	4,814.12	301.61
251	8	SF	Small Hotel	23	788.29	603.75	184.54	27.27	111.86	381.70	58.34
252	8	SF	Small Office	10	67.79	63.96	3.83	0.71	5.22	17.82	8.56
253	8	SF	Retail - Stand Alone	16	326.81	279.27	47.54	47.54	17.48	59.66	31.25
254	8	SF	Strip Mall	15	331.02	279.49	51.53	51.53	19.64	67.02	35.49
255	8	SF	Super Market	17	2,072.73	1,703.23	369.49	307.63	15.21	51.89	125.44
256	8	SF	Warehouse	1	303.05	236.06	66.99	66.99	3.79	12.94	12.89

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
257	9	LA	Restaurant	37	647.69	319.61	328.09	45.16	23.17	79.05	28.09
258	9	LA	Hospital	8	12,865.10	9,161.59	3,703.51	3,155.73	3,825.09	13,051.75	872.93
259	9	LA	Large Hotel	21	4,864.09	2,850.19	2,013.91	125.62	1,220.69	4,165.17	306.94
260	9	LA	Large Office	13	6,478.52	6,348.78	129.74	77.09	1,252.42	4,273.44	152.89
261	9	LA	Medium Office	10	671.83	663.23	8.59	0.34	99.50	339.50	17.75
262	9	LA	Midrise Apartment	30	317.36	244.67	72.69	6.69	38.63	131.80	9.96
263	9	LA	Out Patient Clinic	6	2,093.93	1,319.05	774.88	712.07	336.19	1,147.13	227.19
264	9	LA	Primary School	4	1,061.47	900.71	160.76	54.91	122.24	417.11	36.56
265	9	LA	Fast Food Restaurant	35	382.28	193.72	188.57	12.05	9.08	30.99	15.60
266	9	LA	Secondary School	5	3,693.56	3,176.37	517.18	319.35	1,179.78	4,025.58	298.74
267	9	LA	Small Hotel	22	775.04	603.52	171.51	25.64	110.88	378.35	59.08
268	9	LA	Small Office	10	68.61	65.16	3.45	0.42	6.00	20.47	8.99
269	9	LA	Retail - Stand Alone	15	360.63	322.95	37.68	37.68	32.65	111.40	59.77
270	9	LA	Strip Mall	15	346.74	297.44	49.31	49.31	31.41	107.18	41.68
271	9	LA	Super Market	17	2,061.78	1,701.04	360.74	299.33	26.69	91.06	120.46
272	9	LA	Warehouse	1	303.71	237.00	66.71	66.71	5.56	18.98	12.07
273	9	SF	Restaurant	37	654.53	316.85	337.68	47.63	20.74	70.75	27.78
274	9	SF	Hospital	8	12,550.43	8,662.23	3,888.19	3,319.72	3,296.98	11,249.76	941.03
275	9	SF	Large Hotel	21	4,777.74	2,545.71	2,232.02	114.79	897.68	3,063.01	324.23
276	9	SF	Large Office	13	6,712.71	6,388.89	323.81	263.39	1,264.47	4,314.56	176.59
277	9	SF	Medium Office	9	715.58	706.32	9.26	0.10	116.26	396.71	21.28
278	9	SF	Midrise Apartment	30	336.68	254.44	82.24	6.56	44.41	151.55	13.94
279	9	SF	Out Patient Clinic	6	2,093.11	1,324.18	768.93	704.87	333.20	1,136.93	229.49
280	9	SF	Primary School	4	1,134.04	927.89	206.14	95.26	142.64	486.69	43.32
281	9	SF	Fast Food Restaurant	35	385.13	193.65	191.48	12.82	8.44	28.81	16.20
282	9	SF	Secondary School	5	4,028.77	3,436.70	592.08	380.35	1,432.91	4,889.29	305.46
283	9	SF	Small Hotel	22	792.28	608.43	183.85	26.58	115.50	394.10	59.38
284	9	SF	Small Office	10	68.69	64.82	3.88	0.76	5.89	20.09	8.76
285	9	SF	Retail - Stand Alone	16	337.45	284.69	52.76	52.76	22.25	75.92	31.85
286	9	SF	Strip Mall	16	343.27	285.44	57.84	57.84	24.85	84.80	36.23
287	9	SF	Super Market	17	2,079.46	1,702.11	377.36	315.49	20.96	71.52	127.63
288	9	SF	Warehouse	1	306.05	237.90	68.15	68.15	5.42	18.49	13.11

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
289	10	LA	Restaurant	37	662.30	324.91	337.39	54.46	27.84	94.98	28.78
290	10	LA	Hospital	8	12,663.93	9,084.55	3,579.38	3,031.60	3,718.36	12,687.55	879.80
291	10	LA	Large Hotel	21	4,869.08	2,831.89	2,037.19	148.91	1,200.28	4,095.51	308.71
292	10	LA	Large Office	13	6,464.95	6,319.53	145.42	92.77	1,218.78	4,158.63	161.08
293	10	LA	Medium Office	10	680.93	672.17	8.76	0.51	104.47	356.47	18.91
294	10	LA	Midrise Apartment	28	326.54	249.08	77.46	11.47	42.03	143.40	10.96
295	10	LA	Out Patient Clinic	6	2,106.37	1,337.31	769.06	706.25	338.22	1,154.05	233.26
296	10	LA	Primary School	4	1,081.46	910.30	171.16	65.31	130.20	444.25	38.14
297	10	LA	Fast Food Restaurant	24	388.84	196.06	192.79	16.27	11.24	38.35	15.84
298	10	LA	Secondary School	5	3,803.17	3,241.10	562.07	364.24	1,237.03	4,220.92	306.43
299	10	LA	Small Hotel	22	785.42	608.38	177.03	31.16	114.47	390.59	60.38
300	10	LA	Small Office	10	69.72	66.03	3.69	0.67	6.57	22.42	9.28
301	10	LA	Retail - Stand Alone	16	371.23	329.57	41.66	41.66	37.82	129.05	61.19
302	10	LA	Strip Mall	16	356.30	303.08	53.22	53.22	36.02	122.89	42.70
303	10	LA	Super Market	17	2,061.68	1,684.53	377.15	315.74	34.17	116.60	123.43
304	10	LA	Warehouse	1	318.07	239.77	78.30	78.30	7.49	25.54	12.90
305	10	SF	Restaurant	37	669.33	322.24	347.08	57.04	25.50	87.02	28.46
306	10	SF	Hospital	8	12,432.70	8,649.42	3,783.28	3,214.80	3,241.36	11,059.96	953.06
307	10	SF	Large Hotel	21	4,786.34	2,530.18	2,256.16	138.93	879.19	2,999.92	326.71
308	10	SF	Large Office	13	6,688.73	6,362.16	326.57	266.14	1,230.09	4,197.23	187.31
309	10	SF	Medium Office	9	725.12	715.79	9.34	0.18	122.76	418.89	22.77
310	10	SF	Midrise Apartment	28	346.26	259.62	86.64	10.96	48.31	164.83	15.22
311	10	SF	Out Patient Clinic	6	2,115.07	1,346.56	768.52	704.46	338.31	1,154.37	236.09
312	10	SF	Primary School	4	1,157.91	937.89	220.03	109.14	150.78	514.48	45.08
313	10	SF	Fast Food Restaurant	24	391.93	196.09	195.83	17.18	10.69	36.49	16.44
314	10	SF	Secondary School	5	4,146.38	3,500.90	645.47	433.75	1,491.74	5,090.03	310.91
315	10	SF	Small Hotel	22	803.80	614.35	189.45	32.18	119.94	409.25	60.88
316	10	SF	Small Office	10	69.98	65.73	4.24	1.13	6.54	22.30	9.02
317	10	SF	Retail - Stand Alone	16	347.79	290.18	57.61	57.61	26.94	91.92	32.63
318	10	SF	Strip Mall	15	352.60	290.81	61.79	61.79	29.37	100.20	37.08
319	10	SF	Super Market	17	2,075.29	1,684.48	390.81	328.94	27.06	92.34	130.82
320	10	SF	Warehouse	1	321.15	240.70	80.44	80.44	7.33	25.01	13.99

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
321	11	LA	Restaurant	26	703.55	322.71	380.84	97.91	26.25	89.58	28.45
322	11	LA	Hospital	7	13,200.69	9,215.93	3,984.76	3,436.98	3,795.37	12,950.34	870.14
323	11	LA	Large Hotel	20	4,902.58	2,752.96	2,149.62	261.33	1,124.53	3,837.05	306.27
324	11	LA	Large Office	12	6,420.46	6,042.28	378.18	325.53	992.18	3,385.47	152.64
325	11	LA	Medium Office	9	700.47	687.79	12.68	4.42	90.15	307.60	18.55
326	11	LA	Midrise Apartment	28	352.13	243.98	108.15	42.16	36.76	125.42	11.15
327	11	LA	Out Patient Clinic	8	2,139.04	1,320.88	818.17	755.36	303.21	1,034.59	225.91
328	11	LA	Primary School	4	1,124.83	889.28	235.55	129.71	111.82	381.53	35.69
329	11	LA	Fast Food Restaurant	24	404.29	194.96	209.33	32.81	10.81	36.89	15.53
330	11	LA	Secondary School	31	4,053.13	3,094.08	959.05	761.22	1,097.69	3,745.46	300.01
331	11	LA	Small Hotel	20	783.94	587.72	196.22	50.34	96.58	329.56	57.18
332	11	LA	Small Office	10	71.96	64.91	7.05	4.03	5.81	19.83	8.93
333	11	LA	Retail - Stand Alone	15	418.16	324.64	93.52	93.52	34.36	117.23	59.33
334	11	LA	Strip Mall	15	404.98	298.44	106.54	106.54	32.54	111.02	41.59
335	11	LA	Super Market	17	2,156.09	1,616.88	539.22	477.81	34.12	116.41	118.37
336	11	LA	Warehouse	1	366.62	240.14	126.48	126.48	7.55	25.75	13.25
337	11	SF	Restaurant	26	712.37	319.64	392.73	102.68	24.15	82.41	27.50
338	11	SF	Hospital	8	13,092.44	8,818.50	4,273.94	3,705.46	3,355.43	11,449.19	938.94
339	11	SF	Large Hotel	21	4,845.64	2,465.78	2,379.86	262.63	819.53	2,796.36	322.93
340	11	SF	Large Office	12	6,802.33	6,072.83	729.50	669.07	993.36	3,389.48	178.07
341	11	SF	Medium Office	14	756.84	745.64	11.20	2.04	105.98	361.62	22.36
342	11	SF	Midrise Apartment	28	373.13	253.06	120.07	44.39	42.38	144.59	14.61
343	11	SF	Out Patient Clinic	8	2,153.58	1,334.82	818.76	754.71	301.22	1,027.81	229.08
344	11	SF	Primary School	4	1,238.89	912.94	325.96	215.07	128.37	438.01	42.59
345	11	SF	Fast Food Restaurant	24	408.50	195.25	213.25	34.59	10.48	35.75	16.18
346	11	SF	Secondary School	31	4,463.31	3,314.36	1,148.94	937.22	1,307.87	4,462.62	309.31
347	11	SF	Small Hotel	20	802.34	592.22	210.12	52.85	100.59	343.24	57.33
348	11	SF	Small Office	10	73.86	64.99	8.88	5.76	5.83	19.90	8.99
349	11	SF	Retail - Stand Alone	15	406.29	287.63	118.67	118.67	24.85	84.79	31.65
350	11	SF	Strip Mall	15	408.51	287.84	120.67	120.67	26.95	91.97	36.57
351	11	SF	Super Market	17	2,181.32	1,616.60	564.72	502.86	27.47	93.72	125.51
352	11	SF	Warehouse	1	371.94	241.21	130.73	130.73	7.49	25.56	14.38

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
353	12	LA	Restaurant	26	697.25	316.39	380.86	97.93	20.31	69.30	28.09
354	12	LA	Hospital	7	13,255.08	9,216.10	4,038.98	3,491.20	3,913.89	13,354.76	865.85
355	12	LA	Large Hotel	20	4,848.39	2,716.29	2,132.09	243.81	1,089.98	3,719.17	304.56
356	12	LA	Large Office	12	6,361.57	6,051.81	309.75	257.10	1,012.35	3,454.27	146.11
357	12	LA	Medium Office	9	681.25	669.85	11.40	3.14	79.99	272.93	17.31
358	12	LA	Midrise Apartment	30	339.46	238.73	100.72	34.73	32.77	111.82	9.90
359	12	LA	Out Patient Clinic	6	2,095.14	1,273.32	821.82	759.01	291.42	994.36	222.01
360	12	LA	Primary School	4	1,102.81	874.06	228.75	122.90	98.18	335.00	34.23
361	12	LA	Fast Food Restaurant	24	400.07	192.01	208.06	31.54	8.04	27.44	15.38
362	12	LA	Secondary School	31	3,908.89	2,974.06	934.82	736.99	984.79	3,360.23	293.20
363	12	LA	Small Hotel	22	779.45	582.53	196.93	51.05	92.52	315.68	56.28
364	12	LA	Small Office	10	70.09	64.01	6.08	3.05	5.10	17.39	8.75
365	12	LA	Retail - Stand Alone	15	406.58	318.78	87.80	87.80	29.49	100.61	58.44
366	12	LA	Strip Mall	15	395.57	293.65	101.92	101.92	28.45	97.08	40.89
367	12	LA	Super Market	17	2,171.31	1,645.65	525.67	464.26	25.78	87.95	116.97
368	12	LA	Warehouse	1	357.89	237.89	119.99	119.99	5.71	19.49	12.84
369	12	SF	Restaurant	26	706.09	313.45	392.65	102.60	18.36	62.66	27.11
370	12	SF	Hospital	7	13,084.38	8,785.81	4,298.57	3,730.09	3,459.77	11,805.23	930.99
371	12	SF	Large Hotel	21	4,838.64	2,482.07	2,356.57	239.33	838.19	2,860.03	321.13
372	12	SF	Large Office	12	6,713.73	6,084.21	629.52	569.10	1,015.92	3,466.45	170.12
373	12	SF	Medium Office	9	731.28	720.77	10.51	1.35	93.86	320.25	20.87
374	12	SF	Midrise Apartment	28	357.52	247.33	110.19	34.51	38.21	130.38	13.06
375	12	SF	Out Patient Clinic	6	2,076.88	1,273.58	803.31	739.26	285.16	973.01	221.24
376	12	SF	Primary School	4	1,205.35	895.78	309.58	198.69	112.70	384.54	41.25
377	12	SF	Fast Food Restaurant	24	404.02	192.24	211.77	33.11	7.67	26.16	16.02
378	12	SF	Secondary School	31	4,283.18	3,189.97	1,093.21	881.49	1,189.91	4,060.12	303.22
379	12	SF	Small Hotel	22	797.49	586.83	210.66	53.39	96.58	329.53	56.40
380	12	SF	Small Office	10	71.38	63.97	7.41	4.29	5.06	17.27	8.75
381	12	SF	Retail - Stand Alone	15	396.16	282.52	113.64	113.64	20.35	69.43	31.20
382	12	SF	Strip Mall	15	398.38	282.79	115.58	115.58	22.57	77.02	35.92
383	12	SF	Super Market	17	2,198.84	1,647.34	551.51	489.64	20.64	70.44	124.02
384	12	SF	Warehouse	1	362.63	238.83	123.80	123.80	5.58	19.05	13.91

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
385	13	LA	Restaurant	25	690.73	330.08	360.65	77.72	33.39	113.93	28.37
386	13	LA	Hospital	7	12,927.58	9,107.72	3,819.86	3,272.08	3,810.39	13,001.60	874.81
387	13	LA	Large Hotel	20	4,898.72	2,806.17	2,092.55	204.26	1,176.06	4,012.87	306.39
388	13	LA	Large Office	12	6,532.39	6,280.33	252.06	199.41	1,188.58	4,055.60	161.03
389	13	LA	Medium Office	10	709.54	698.38	11.16	2.91	114.44	390.48	20.31
390	13	LA	Midrise Apartment	28	350.67	257.50	93.17	27.18	48.82	166.57	12.60
391	13	LA	Out Patient Clinic	8	2,087.54	1,313.67	773.87	711.06	337.81	1,152.65	225.69
392	13	LA	Primary School	4	1,130.86	926.81	204.05	98.20	145.39	496.09	39.34
393	13	LA	Fast Food Restaurant	24	400.27	198.43	201.84	25.32	13.98	47.71	15.45
394	13	LA	Secondary School	31	4,123.31	3,343.52	779.79	581.96	1,331.98	4,544.90	312.41
395	13	LA	Small Hotel	20	796.67	610.07	186.60	40.73	117.78	401.86	58.60
396	13	LA	Small Office	10	72.19	66.77	5.42	2.39	7.59	25.91	9.00
397	13	LA	Retail - Stand Alone	19	406.03	335.09	70.93	70.93	45.46	155.11	58.88
398	13	LA	Strip Mall	19	389.93	308.11	81.82	81.82	42.61	145.39	41.16
399	13	LA	Super Market	17	2,145.55	1,697.54	448.01	386.59	46.13	157.39	118.23
400	13	LA	Warehouse	2	346.65	243.36	103.29	103.29	10.95	37.37	13.04
401	13	SF	Restaurant	25	696.40	325.85	370.55	80.51	30.19	103.03	27.35
402	13	SF	Hospital	8	12,683.11	8,667.93	4,015.18	3,446.70	3,345.73	11,416.10	942.14
403	13	SF	Large Hotel	21	4,834.83	2,520.65	2,314.17	196.94	871.79	2,974.67	323.38
404	13	SF	Large Office	12	6,797.69	6,307.09	490.60	430.18	1,183.60	4,038.62	188.95
405	13	SF	Medium Office	11	757.33	746.88	10.44	1.28	133.31	454.86	24.37
406	13	SF	Midrise Apartment	28	369.79	267.46	102.33	26.65	54.72	186.70	16.66
407	13	SF	Out Patient Clinic	8	2,085.92	1,321.76	764.16	700.10	333.93	1,139.43	229.46
408	13	SF	Primary School	4	1,219.73	952.94	266.79	155.90	165.48	564.64	45.24
409	13	SF	Fast Food Restaurant	24	403.33	198.36	204.98	26.31	13.30	45.39	16.08
410	13	SF	Secondary School	31	4,463.78	3,561.86	901.92	690.19	1,546.26	5,276.07	315.81
411	13	SF	Small Hotel	20	815.14	615.85	199.29	42.02	123.07	419.92	59.01
412	13	SF	Small Office	10	73.05	66.61	6.44	3.33	7.58	25.87	8.86
413	13	SF	Retail - Stand Alone	15	384.15	294.50	89.66	89.66	32.23	109.98	31.44
414	13	SF	Strip Mall	15	385.25	294.92	90.33	90.33	34.56	117.93	36.03
415	13	SF	Super Market	17	2,159.49	1,695.94	463.55	401.69	37.82	129.04	125.32
416	13	SF	Warehouse	2	350.86	244.33	106.53	106.53	10.82	36.92	14.15

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
417	14	LA	Restaurant	25	707.77	330.23	377.54	94.61	32.71	111.61	29.59
418	14	LA	Hospital	7	12,806.20	9,249.09	3,557.11	3,009.33	3,398.31	11,595.50	888.03
419	14	LA	Large Hotel	20	4,896.83	2,752.69	2,144.13	255.84	1,120.65	3,823.81	310.70
420	14	LA	Large Office	12	6,298.73	5,999.65	299.07	246.43	931.18	3,177.33	169.38
421	14	LA	Medium Office	11	711.32	697.77	13.55	5.29	105.90	361.36	21.21
422	14	LA	Midrise Apartment	28	354.47	248.83	105.64	39.65	40.45	138.03	12.30
423	14	LA	Out Patient Clinic	8	2,251.03	1,481.36	769.67	706.86	317.68	1,083.95	240.65
424	14	LA	Primary School	4	1,154.44	912.58	241.85	136.01	131.39	448.33	39.32
425	14	LA	Fast Food Restaurant	24	409.16	198.51	210.65	34.13	13.83	47.19	16.15
426	14	LA	Secondary School	31	4,133.20	3,179.18	954.02	756.18	1,169.70	3,991.17	313.61
427	14	LA	Small Hotel	20	793.93	598.18	195.76	49.88	103.22	352.19	60.78
428	14	LA	Small Office	10	72.64	66.62	6.01	2.99	6.77	23.10	9.69
429	14	LA	Retail - Stand Alone	19	421.45	334.91	86.54	86.54	41.03	140.00	63.13
430	14	LA	Strip Mall	19	403.94	306.17	97.77	97.77	37.71	128.69	44.13
431	14	LA	Super Market	17	2,098.54	1,565.39	533.14	471.73	43.36	147.94	127.18
432	14	LA	Warehouse	1	375.81	243.91	131.89	131.89	10.01	34.16	14.55
433	14	SF	Restaurant	25	714.64	327.84	386.80	96.75	30.60	104.41	29.33
434	14	SF	Hospital	8	12,797.97	8,982.24	3,815.73	3,247.25	3,019.83	10,304.08	968.47
435	14	SF	Large Hotel	21	4,866.03	2,502.36	2,363.67	246.44	849.86	2,899.85	329.55
436	14	SF	Large Office	12	6,576.50	6,046.23	530.27	469.85	943.28	3,218.59	198.74
437	14	SF	Medium Office	11	756.89	744.45	12.44	3.28	123.75	422.26	25.05
438	14	SF	Midrise Apartment	28	372.16	259.86	112.29	36.61	47.57	162.30	16.22
439	14	SF	Out Patient Clinic	8	2,278.70	1,498.28	780.42	716.37	321.88	1,098.29	244.06
440	14	SF	Primary School	4	1,263.44	938.85	324.59	213.71	150.23	512.60	46.49
441	14	SF	Fast Food Restaurant	24	412.38	198.71	213.67	35.01	13.39	45.68	16.81
442	14	SF	Secondary School	31	4,524.18	3,419.24	1,104.94	893.22	1,400.81	4,779.74	321.84
443	14	SF	Small Hotel	20	813.45	605.12	208.33	51.06	109.33	373.06	61.38
444	14	SF	Small Office	10	73.54	66.34	7.20	4.08	6.73	22.96	9.45
445	14	SF	Retail - Stand Alone	15	402.18	294.27	107.91	107.91	29.74	101.49	33.71
446	14	SF	Strip Mall	15	400.57	294.13	106.44	106.44	31.31	106.82	38.50
447	14	SF	Super Market	17	2,113.54	1,563.41	550.12	488.26	34.78	118.67	135.28
448	14	SF	Warehouse	1	383.43	245.09	138.34	138.34	9.99	34.07	15.74

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
449	15	LA	Restaurant	27	675.54	358.64	316.91	33.98	62.63	213.69	27.16
450	15	LA	Hospital	8	12,898.88	9,316.59	3,582.29	3,034.51	3,680.99	12,560.05	881.87
451	15	LA	Large Hotel	21	4,996.69	3,009.48	1,987.21	98.92	1,376.24	4,695.92	307.41
452	15	LA	Large Office	12	6,815.19	6,709.59	105.61	52.96	1,520.65	5,188.66	182.35
453	15	LA	Medium Office	11	772.32	763.76	8.56	0.30	195.53	667.18	27.29
454	15	LA	Midrise Apartment	28	361.68	289.47	72.21	6.21	77.33	263.86	16.05
455	15	LA	Out Patient Clinic	8	2,145.95	1,488.74	657.21	594.40	438.16	1,495.06	226.90
456	15	LA	Primary School	5	1,192.38	1,048.42	143.96	38.11	257.49	878.61	48.21
457	15	LA	Fast Food Restaurant	27	400.51	213.80	186.71	10.19	28.89	98.56	15.28
458	15	LA	Secondary School	31	4,528.48	4,121.53	406.96	209.12	2,074.61	7,078.84	343.56
459	15	LA	Small Hotel	20	827.02	660.98	166.04	20.17	166.36	567.66	61.10
460	15	LA	Small Office	11	75.61	72.30	3.31	0.28	12.77	43.57	9.36
461	15	LA	Retail - Stand Alone	19	396.05	369.21	26.84	26.84	81.16	276.91	57.63
462	15	LA	Strip Mall	19	374.26	339.82	34.44	34.44	75.25	256.75	40.21
463	15	LA	Super Market	18	2,019.70	1,737.62	282.08	220.67	96.84	330.44	116.60
464	15	LA	Warehouse	2	308.85	253.07	55.78	55.78	21.25	72.51	12.44
465	15	SF	Restaurant	27	678.24	353.28	324.96	34.92	57.59	196.50	26.83
466	15	SF	Hospital	8	12,475.29	8,829.05	3,646.25	3,077.77	3,146.66	10,736.86	945.55
467	15	SF	Large Hotel	21	4,806.13	2,601.58	2,204.54	87.31	946.41	3,229.30	325.45
468	15	SF	Large Office	12	6,947.55	6,735.09	212.45	152.03	1,510.69	5,154.68	215.86
469	15	SF	Medium Office	11	821.59	812.32	9.27	0.11	225.65	769.95	33.46
470	15	SF	Midrise Apartment	28	384.31	302.74	81.56	5.88	84.89	289.64	21.77
471	15	SF	Out Patient Clinic	8	2,091.05	1,487.44	603.61	539.56	429.00	1,463.81	229.44
472	15	SF	Primary School	5	1,270.78	1,098.72	172.06	61.18	298.44	1,018.32	57.53
473	15	SF	Fast Food Restaurant	27	401.47	212.22	189.25	10.59	26.75	91.27	15.83
474	15	SF	Secondary School	31	4,830.93	4,375.40	455.53	243.79	2,328.81	7,946.22	342.62
475	15	SF	Small Hotel	20	847.65	669.87	177.78	20.51	174.38	595.01	61.97
476	15	SF	Small Office	11	75.31	71.70	3.61	0.49	12.70	43.34	8.82
477	15	SF	Retail - Stand Alone	19	354.05	319.36	34.69	34.69	58.20	198.58	30.73
478	15	SF	Strip Mall	19	357.91	320.63	37.28	37.28	61.51	209.88	34.76
479	15	SF	Super Market	18	2,012.71	1,730.03	282.68	220.82	83.04	283.36	123.60
480	15	SF	Warehouse	2	311.25	254.06	57.19	57.19	21.09	71.95	13.59

Building #	Zone	Build	Type	Cluster	Total Energy [MWh]	Electricity [MWh]	Natural Gas [MWh]	Heating [MWh]	Cooling [MWh]	Cooling [MBtu]	Fans [MWh]
481	16	LA	Restaurant	37	765.94	311.54	454.40	171.47	11.78	40.19	32.44
482	16	LA	Hospital	8	12,703.36	8,891.67	3,811.69	3,263.91	3,369.71	11,497.92	885.49
483	16	LA	Large Hotel	20	4,985.29	2,573.52	2,411.76	523.47	940.11	3,207.79	312.65
484	16	LA	Large Office	12	6,280.44	5,562.86	717.59	664.94	589.90	2,012.82	154.38
485	16	LA	Medium Office	14	707.01	685.44	21.56	13.31	42.58	145.29	18.17
486	16	LA	Midrise Apartment	30	400.59	228.29	172.30	106.31	19.09	65.14	13.12
487	16	LA	Out Patient Clinic	14	2,196.59	1,332.06	864.54	801.73	225.45	769.27	249.16
488	16	LA	Primary School	3	1,199.94	822.07	377.87	272.02	48.61	165.86	32.04
489	16	LA	Fast Food Restaurant	35	432.38	188.78	243.61	67.09	4.25	14.51	16.74
490	16	LA	Secondary School	5	4,280.61	2,574.53	1,706.09	1,508.26	589.71	2,012.16	291.64
491	16	LA	Small Hotel	21	795.91	562.96	232.95	87.08	64.72	220.84	60.81
492	16	LA	Small Office	10	75.28	63.08	12.20	9.18	2.97	10.14	9.94
493	16	LA	Retail - Stand Alone	15	479.33	313.83	165.49	165.49	16.00	54.59	66.37
494	16	LA	Strip Mall	15	468.46	286.68	181.78	181.78	15.36	52.40	46.99
495	16	LA	Super Market	29	2,311.63	1,531.74	779.89	718.48	12.06	41.16	130.06
496	16	LA	Warehouse	1	449.94	238.18	211.76	211.76	2.48	8.45	16.35
497	16	SF	Restaurant	37	777.96	309.03	468.93	178.88	10.42	35.54	31.33
498	16	SF	Hospital	7	13,131.01	8,832.43	4,298.58	3,730.11	3,212.19	10,960.46	975.51
499	16	SF	Large Hotel	20	5,094.10	2,437.50	2,656.60	539.36	784.66	2,677.35	331.04
500	16	SF	Large Office	12	6,905.59	5,620.84	1,284.75	1,224.33	608.89	2,077.62	185.07
501	16	SF	Medium Office	14	769.42	752.01	17.41	8.25	50.38	171.91	22.14
502	16	SF	Midrise Apartment	30	415.19	233.76	181.43	105.75	23.17	79.06	14.51
503	16	SF	Out Patient Clinic	14	2,240.55	1,352.26	888.29	824.23	226.27	772.06	252.00
504	16	SF	Primary School	3	1,404.68	841.97	562.71	451.83	56.03	191.17	43.90
505	16	SF	Fast Food Restaurant	35	437.61	189.09	248.52	69.86	3.90	13.31	17.44
506	16	SF	Secondary School	5	4,828.64	2,741.62	2,087.02	1,875.28	725.96	2,477.06	320.82
507	16	SF	Small Hotel	21	815.26	566.26	248.99	91.73	66.62	227.32	60.62
508	16	SF	Small Office	10	78.44	63.10	15.34	12.22	2.82	9.63	10.11
509	16	SF	Retail - Stand Alone	16	486.76	277.44	209.32	209.32	10.26	35.00	35.41
510	16	SF	Strip Mall	16	482.15	277.05	205.09	205.09	11.49	39.19	41.23
511	16	SF	Super Market	29	2,363.12	1,536.80	826.31	764.46	9.02	30.78	139.09
512	16	SF	Warehouse	1	463.22	238.99	224.23	224.23	2.42	8.26	17.21

Appendix C: Cluster Data

Aggregate Zones per Cluster

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Zone 1	2		3	1		2	2		2	2		1	1			4					4												2	2		2		2
Zone 2	2		2		2	2	2		2	2		1		1	2	2				1	1	2								2			2		2		2	
Zone 3	2		2	1	1	2	2		1	3			2			4					4												2	2		2		2
Zone 4	2		2		2	2	1	1	2	2		2			2	2	2				2	2					2								2		2	
Zone 5	2		2	1	1	2	2		2	2			2			4					1		3										2	2		2		2
Zone 6	2		2		2	2		2	2	2			2			4					2		2			1				1		2		2				2
Zone 7	2		2		2	2		2	2	2			2		1	3					2		2							2		2			2			2
Zone 8	2		2		2	2		2	2	2			2		2	2	2				2		2							2					2		2	
Zone 9	2			2	2	2		2	1	3			2		2	2	2				2	2								2					2		2	
Zone 10	2			2	2	2		2	1	3			2		1	3	2				2	2		2				2									2	
Zone 11	2			2			1	3	1	2		2		1	4		2			3	1			2		2		2			2							
Zone 12	2			2		2	2		2	2		2			4		2			1	1	2		2		2		1		1	2							
Zone 13		2		2			1	3		3	1	2			2		2		2	3	1			2	2			2			2							
Zone 14	2			2			1	3		2	2	2			2		2		2	3	1			2	2			2			2							
Zone 15		2			2			4			4	2						2	4	2	2						4	2			2							
Zone 16	2		2		2		1	1		2		2		4	2	2				2	2								2	2					2		2	

(Visual Data Available in Package)

Aggregate Build Types per Cluster

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
SF	14	2	9	7	11	11	6	14	11	15	4	8	8	3	11	19	8	1	2	5	18	5	4	5	2	2	3	6	1	6	5	2	4	4	6	3	6	5
LA	14	2	10	8	9	11	9	11	9	19	3	8	7	3	13	13	8	1	6	10	12	5	5	5	2	3	3	5	1	6	5	2	4	4	6	3	6	5

Aggregate Building Types per Cluster

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Large Office												16	15	1																								
Medium Office									20	4	5			3																								
Small Office										30	2																											
Warehouse	28	4																																				
Stand-alone Retail															9	19			4																			
Strip mall															15	13			4																			
Primary School			18	12	2																																	
Secondary School			1	3	18																										10							
Supermarket																	16	2											2			4	8					
Quick Service Restaurant																								10			2							8	12			
Full Service Restaurant																									4	4	2										12	10
Hospital							15	17																														
Outpatient Health Care						22		8						2																								
Small Hotel																				8	6	10	8															
Large Hotel																				7	24		1															
Midrise Apartment																										1	2	11		12						6		